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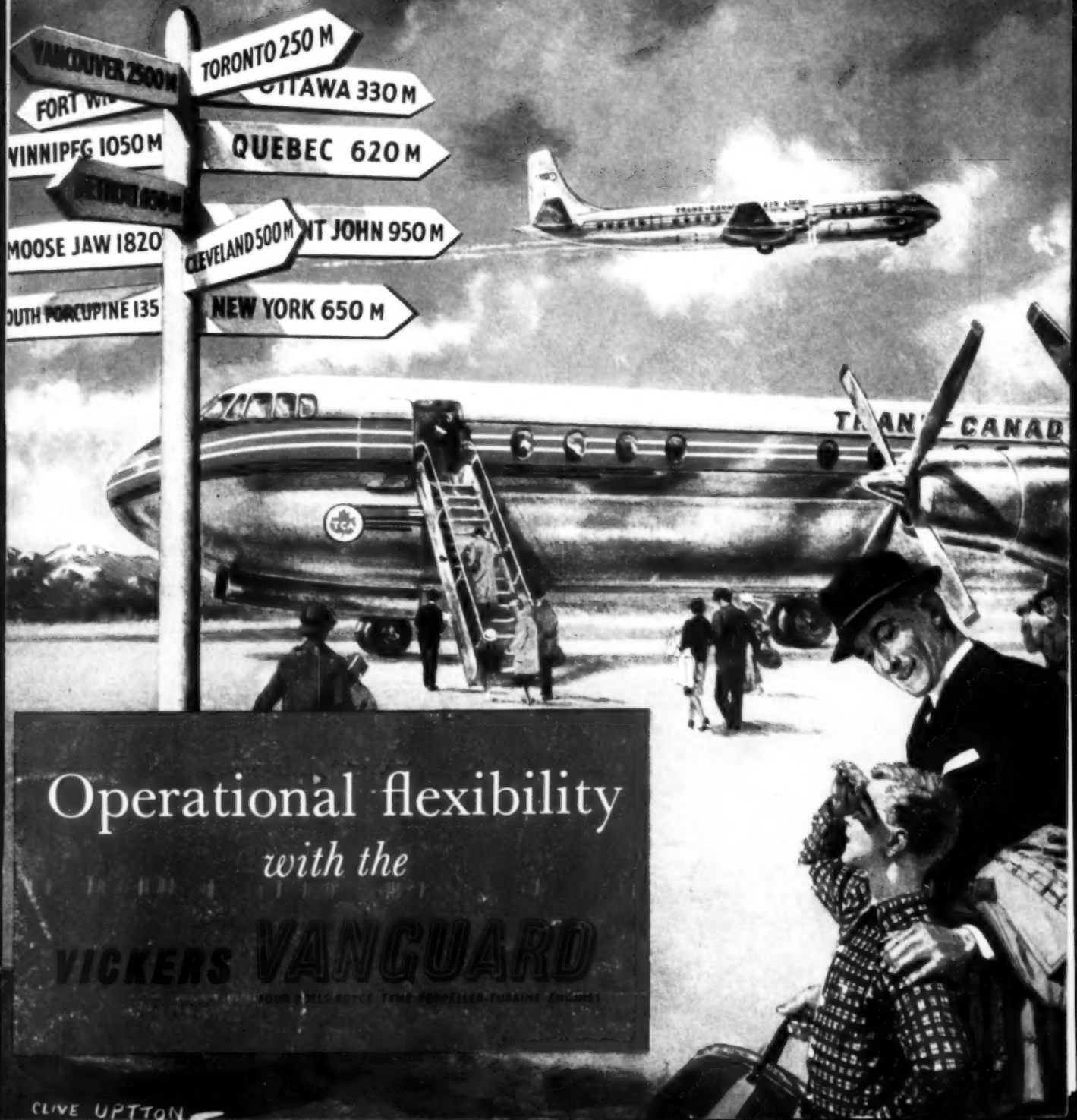

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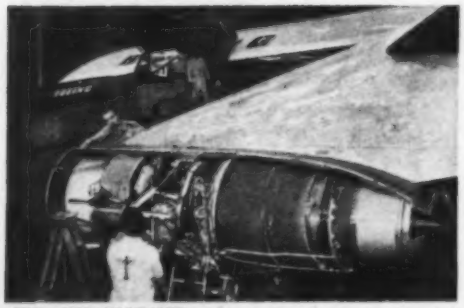
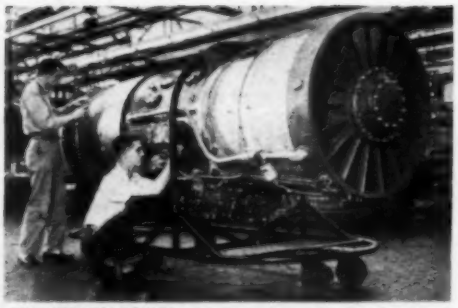


JT3 JET ENGINE, above, is the commercial version of Pratt & Whitney's famous J-57. It is backed by millions of flight hours and an unequalled record of dependability. Airlines have ordered more than 600 JT3 engines for installation in Boeing 707, 720 and Douglas DC-8 jet transports.



JT4 JET ENGINE, above, is more powerful than the JT3. It is a commercial version of Pratt & Whitney's J-75, the first aircraft engine to meet performance estimates and guarantees under actual altitude operating conditions. Commercial airlines have ordered more than 1200 JT4 engines for long-range Boeing 707s and Douglas DC-8s.

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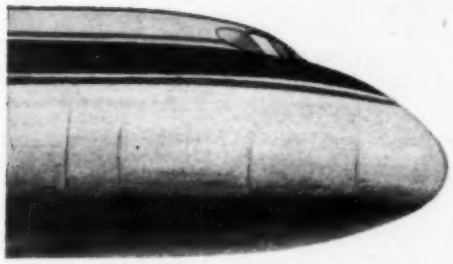

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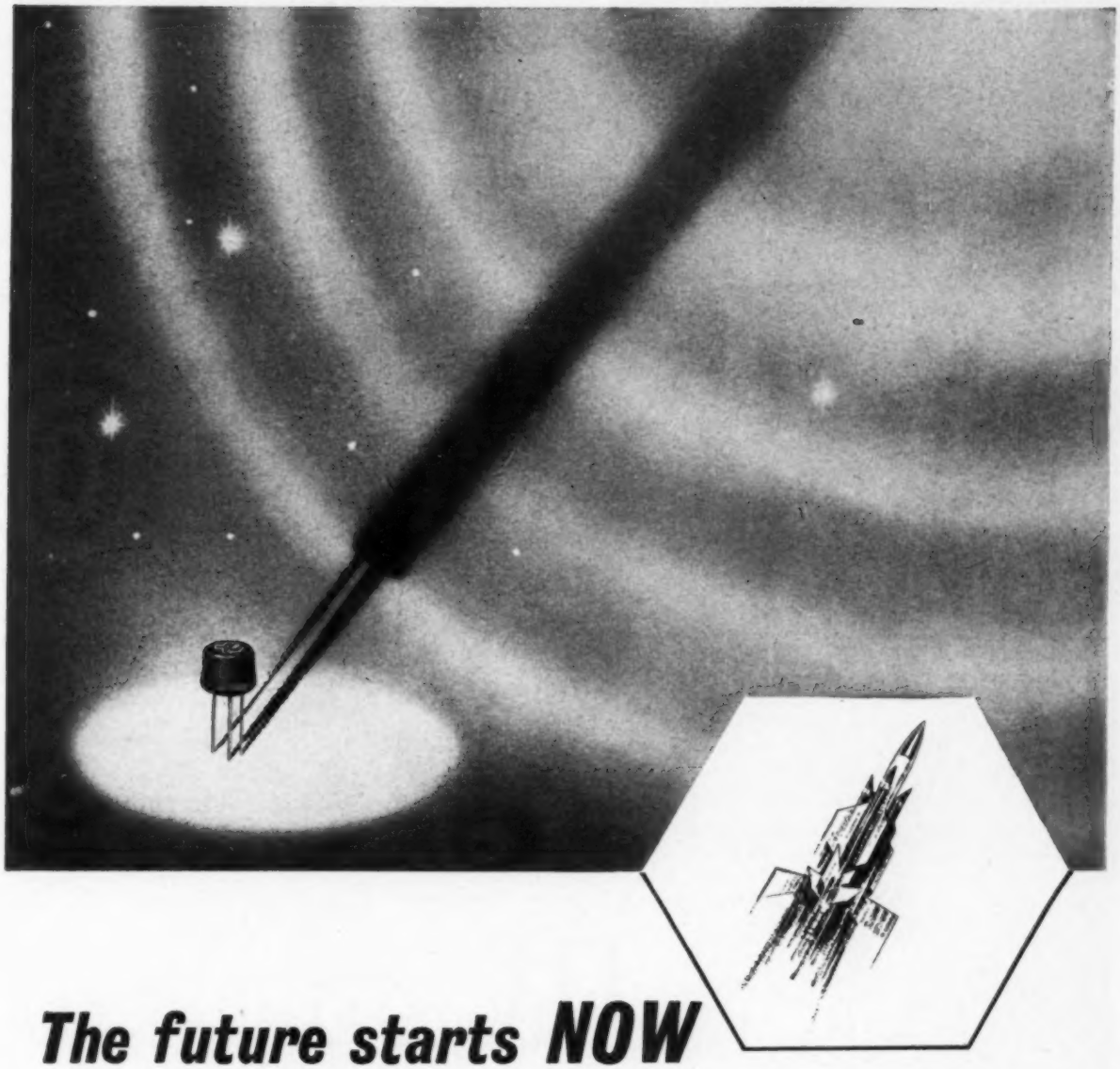

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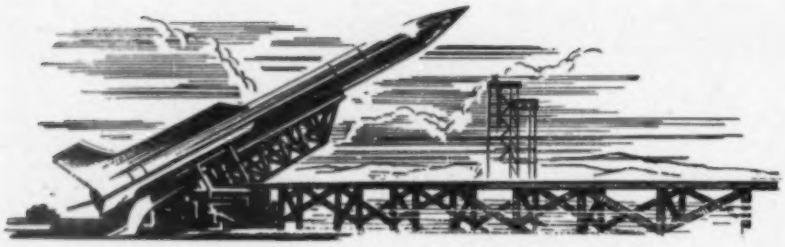

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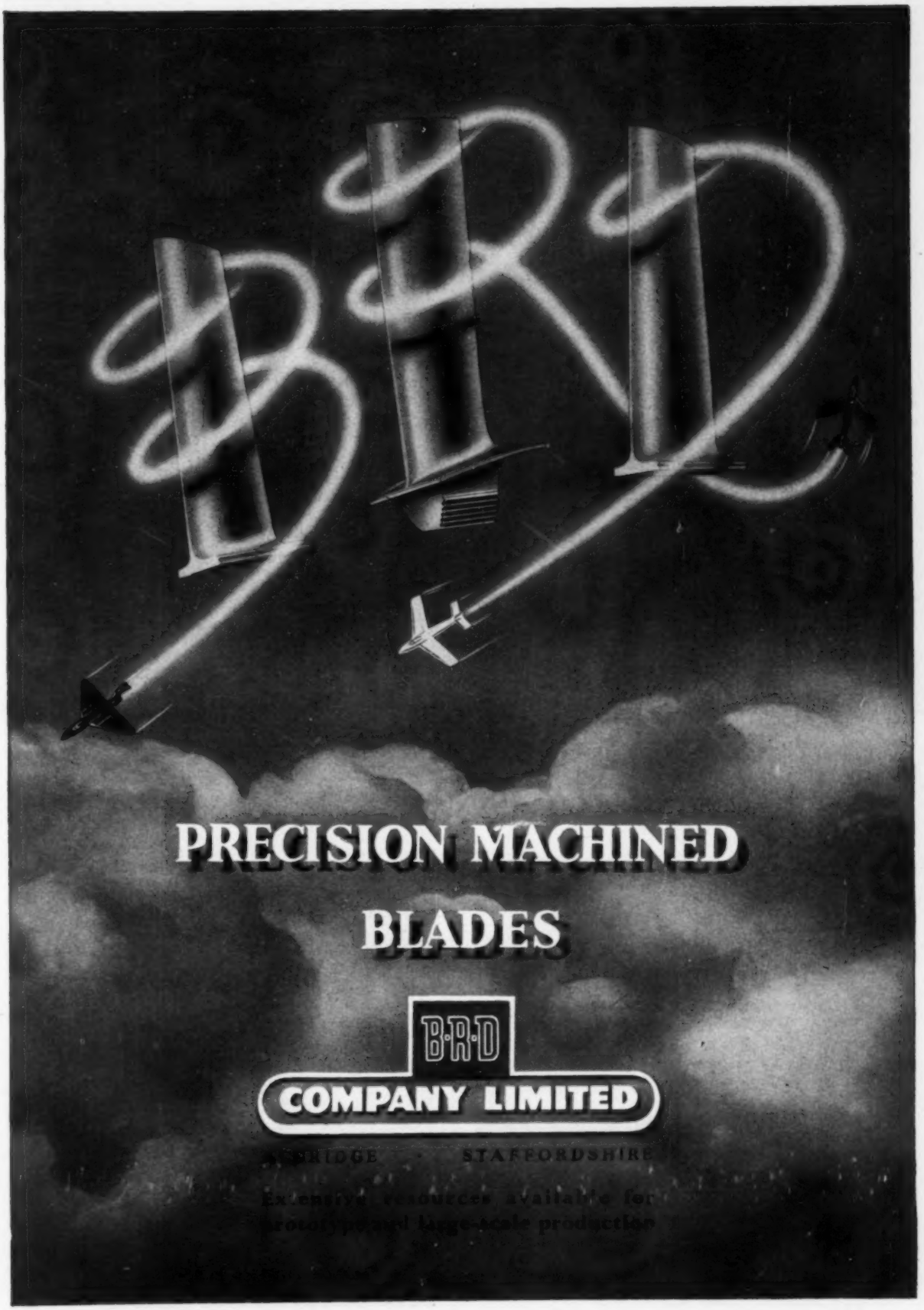
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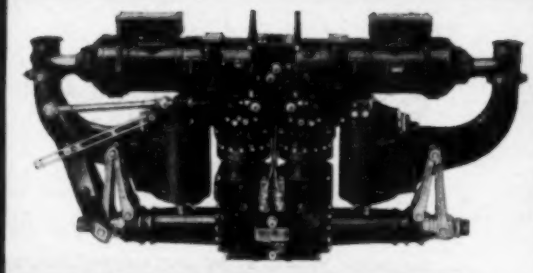

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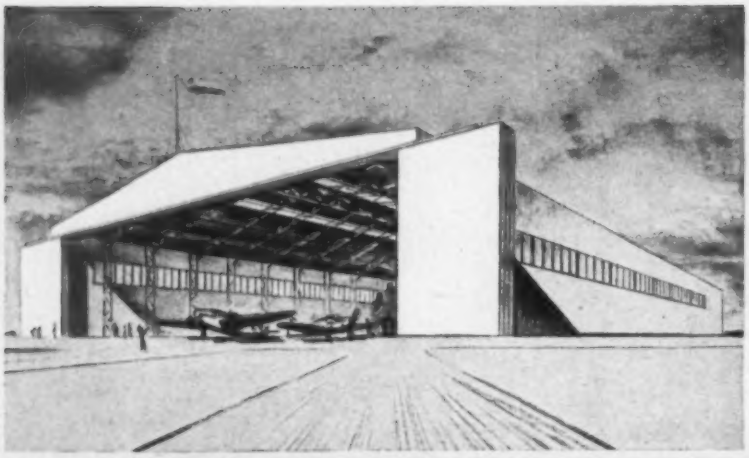

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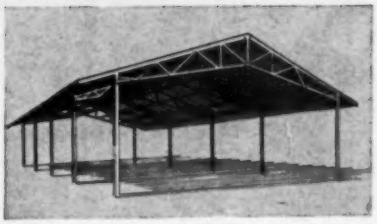

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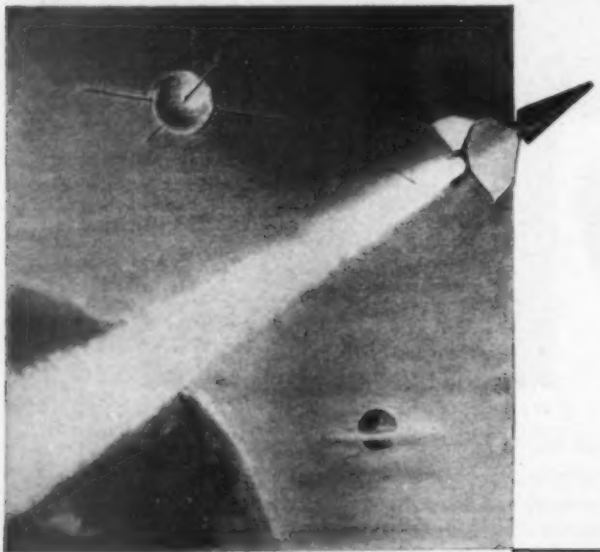

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Oh, pardon me, but I *am* trying to concentrate on your cricket game. Say, what the heck are they clapping for now?

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O.K. O.K., it's the greatest. Holy Mackerel! They've started clapping again

Course they have . . . 100 up. And there's no need to get shirty. All I'm saying is that with a thing like Pacitor the British prove they have the 'know-how' on aircraft fuel tank gauges.

Uhuh. Say, how much longer is this game going on?

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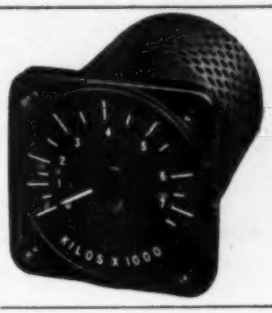

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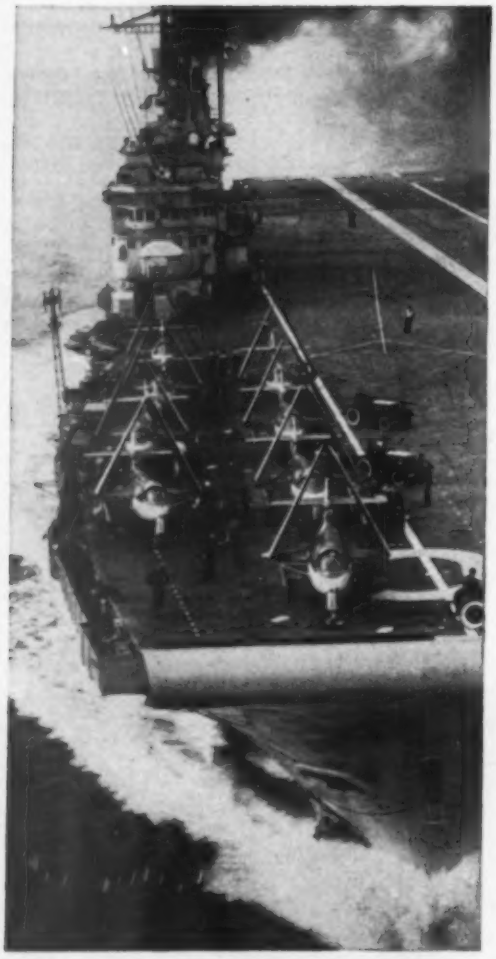
SEA HAWK



Sea Hawks massed on deck of a Royal Navy Carrier.

Long range Gun of Modern Navies

The navies of the future will carry no big guns. Ultimately, the job of bombardment will be taken over by guided missiles; but in the years immediately ahead it will be handled by aircraft. Several of the fleets of NATO are equipping themselves on this modern pattern—equipping themselves with Sea Hawks. The Sea Hawk is the ideal strike aircraft. It can strike heavily—with rockets, bombs, cannon. It can strike far—having longer range than any comparable naval fighter. It can strike fast—at near-sonic speeds. And it can strike either from a carrier or from a land base. Moreover, its uses are not confined to attack. Speed, manœuvrability, and a service ceiling of 50,000 feet combine to make it a most efficient naval interceptor. It is, in fact, an all-purpose fighter—and one which is notably easy to fly.

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FLIGHT
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AIRCRAFT ENGINEER

No 2564 Vol 73 FRIDAY 14 MARCH 1958

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In this Issue

327 Nairobi's New Airport
328 The Future of Air Freight
332 The Canberra Story
340 Canada's Air Defence Policy
342 Test Vehicle Development
351 Research (Blériot Lecture)
352 Nord CT-20 Target

Britannia at the Crossroads

THE tide in the affairs of the Bristol Britannia is now approaching the flood. The big question, as the Spring of 1958 approaches, is whether that flood will lead the Britannia on to great fortune.

No manufacturer with responsibilities to his shareholders could claim to have done more than Bristol Aircraft to ensure that production would meet demand. Britannias are being built by two self-contained production units, the parent one at Bristol, its partner at Shorts in Belfast. But, at this point in the Britannia's fortunes, and ironically for the British aircraft industry, demand does not seem likely to sustain the production machine. Last week came news of 400 redundancies at Bristol, news which gives a keen edge to the question: Can Bristol and Shorts afford to keep tooling and employment up in anticipation of demand, or must the two production machines be geared down—with a consequent discouragement of demand?

Bristol and Shorts have still to complete only a score or more commercial 310s, for B.O.A.C., Canadian Pacific Airlines, Hunting-Clan, and Cubana. All these should be delivered within a year from now. In addition, however, 23 Britannia 250-series are on the lines for R.A.F. Transport Command and for independently operated Government work. The existence of these military orders—increased from 16 a few months ago—is helping to ward off the onset of the decision-point so far as commercial orders are concerned. But that point is approaching fast.

What justification is there for suggesting that Bristol and Shorts must at all costs hang on? As we see it, there are three mainsprings of hope—providing that certain changes of emphasis are made by the makers and the users.

First, and most important, the Britannia's ton-miles will have to be sold at a discount. It will be hardly economic to pit turboprops against jets at the same fare. Passengers and cargo-shippers will of course buy jet seats and jet capacity for the same price. Here is B.O.A.C.'s biggest opportunity to show I.A.T.A. the commercial stuff of which it is made. There should be no shrugging-off the issue because "I.A.T.A. would not agree"—as if I.A.T.A. somehow controlled B.O.A.C.'s destiny. The International Air Transport Association is only as effective as its members.

There is no time to spare: as we report on another page, Pan American's Boeing 707s will be challenging the Britannia over the Atlantic seven short months hence. A great deal hangs upon the differential-fare issue.

Towards Convertibility

Next, the emphasis of Bristol's sales efforts might be switched. The turboprop is the implement with which to prise open the air freight market (see pages 328 and 329 of this issue). The specialist all-cargo aeroplane will come one day: in the meantime, the way to massive air-freighting will be pointed by convertible cargo/passenger airliners. Proof of this is the steady business still being contracted, week after week, by Douglas and Lockheed for new DC-6As and L.1049Hs.

With bigger 250-style doors, stronger floors and perhaps a pulled-out fuselage, the Britannia would be a "convertible" *par excellence*. It will be hard for Bristol to play down the luxury-travel aspect of the Britannia, and difficult for them to resist trying to make it go faster than the Lockheed Electra. But the potential extra power of the Proteus (taking it up to 5,000 e.h.p. for take-off) should be directed towards the maximum exploitation of second-class air transport—to freighting and to cheap-fare passenger haulage.

Finally, B.O.A.C. could help by publishing the profit which Britannias made in their first year. The Corporation's reticence on this vital matter is difficult to understand. B.O.A.C. could also, with seven Britannia 312s delivered, increase the once-weekly frequency of their London - New York service (El Al, with three Britannia 313s, fly thrice-weekly). And the Corporation could fulfil the "express undertaking" given to the Government in 1955 to sell the DC-7Cs when Britannias "are in scheduled service on the North Atlantic." If the Corporation needs the capacity, more Britannias should be bought.

ROTODYNE'S ROYAL VISITOR: Last week the Duke of Edinburgh, accompanied by his Equerry, W/C. H. M. Chinnery, visited White Waltham in order to see the Fairey Rotodyne during its development trials by test pilots Gellatly and Morton. In this group the Duke is in conversation with Mr. Richard Fairey (vice-chairman) and S/L. Gellatly.

FROM ALL QUARTERS

From the Estimates Debate

THE Secretary of State for Air announced during the Air Estimates debate last Monday that in celebration of the R.A.F.'s 40th anniversary the Queen and Prince Philip and other members of the Royal Family will dine at Fighter Command. Other noteworthy points (pending a fuller report next week) were: This year will see the introduction of the Javelin 7 armed with the Firestreak. Later the Javelin 7 and 8 will be given reheat "to extend their effective lives." The P.1 will be improved by having electronic computing equipment "to tell the automatic pilot the place in which to intercept the bomber." Service trials (not firing) of the Bloodhound system will begin at North Coates within a few weeks. There is "a clear and continuing need" for a strike and reconnaissance aircraft in overseas theatres. The R.A.F. is therefore considering the performance which could be offered by types under development or by designs put forward by the industry in reply to the general operational requirement issued last year.

Swiss Sapphires

A HUNDRED Armstrong Siddeley Sapphires are to be built under licence in Switzerland to power Swiss-manufactured P-16s. This was decided on March 7 by the Lower House of the Swiss Parliament, which voted against a proposal to buy the engines direct from Britain.

The Lower House also voted to increase the credit asked for by the Government for the P-16s from £33m to £36m. This increase was to be discussed later by the Upper House.

More U.S. Satellite Failures

AN unsuccessful attempt to launch into orbit a second artificial Earth satellite by means of a modified Jupiter C rocket was made by the U.S. Army at Cape Canaveral last week. The launching took place on Wednesday, March 5, and a later statement said that the rocket's fourth stage had failed to ignite. On Sunday, March 9, the launching of the U.S. Navy's Vanguard satellite was postponed for the third time, within 35 sec of firing, following technical and meteorological difficulties.

Basic Aerothermodynamics

THE DUKE OF EDINBURGH was present at the Royal Institution on Thursday of last week when a paper on *Aerothermodynamics* was delivered by Professor W. R. Hawthorne, M.A., Sc.D.(M.I.T.), F.R.S., F.R.Ae.S., M.I.Mech.E., Professor of Applied Thermodynamics at Cambridge. The lecturer, who was at the R.A.E. and with the Ministry of Supply from 1939 to 1946, was at the Massachusetts Institute of Technology in 1948-51 and 1955-56, being Hunsaker Professor of Aeronautical Engineering during the latter period.

The lecturer introduced his discourse, which was one dealing with basic principles, by saying: "Aerothermodynamics deals with the behaviour of flowing gases in which appreciable changes of temperature or density occur. Much of our knowledge of aerothermodynamics has been acquired as a result of the study and development of new methods of propelling aircraft."

He went on to give examples of aerothermodynamic phenomena which occur in the turbojet engine and explained that, because gas expands as it drops in pressure a convergent/divergent shape is required for a duct or nozzle intended to accelerate it. The maximum flow through such a nozzle, he said, was reached when the gas velocity at the minimum cross-section attained the velocity of sound. In the flow along a long pipe there was a pressure-drop as a result of friction. If heat was added to the flow the expansion of the gas also caused an increase of velocity and a pressure-drop. Heat addition or friction might therefore result in the velocity reaching that of sound. In such a case the flow reached its maximum. These effects limited the amount of air that could be passed through a jet engine and thus set a limit on the power that could be obtained with a given size and weight.

Although combustion in flames was a chemical phenomenon it had been found that rate of combustion was limited by the rate of aerodynamic mixing and turbulence. Close control over mixing and turbulence in the combustion chambers of jet engines had been necessary in order to keep the engines compact. Another problem in combustion was that of keeping the flame alight in the high-speed stream of air. This was often done by stabilizing the flame in the wake of a baffle, where the hot burned gas could re-circulate to light the incoming cold mixture of air and fuel.

The turbojet engine had a compressor and turbine, but it was possible to propel an aircraft by combustion only. The ramjet, for instance, was a tube into which air flowed at one end. Fuel was injected to mix with and burn with the air in the tube and the products of combustion were discharged downstream in a high-speed jet which propelled the aircraft. This device had been called an "aerothermodynamic duct."

Another aerothermodynamic device was the rocket, which had a combustion chamber into which liquids such as oxygen and paraffin were pumped. They burned intensely in the combustion chamber and passed out through a convergent/divergent nozzle into the atmosphere or, perhaps, into space.

Such were the "bones" of Professor Hawthorne's paper; but around these major topics of discussion he wove a detailed thread of exposition and explanation. Moreover, he illustrated his paper with practical demonstrations of turbulence, flow in channels, flame propagation and other suitable subjects for experiment.

Mr. Robert Ross

WE learn with regret that Mr. Robert Ross, F.A.C.C.A., contracts manager of Handley Page, Ltd., and the vice-chairman (and a past chairman) of the S.B.A.C. contracts advisory committee, died on March 6. Mr. Ross, who was born in Edinburgh in 1894, had been with Handley-Page for the past 35 years.

Auster Workmaster

NOW well into its flight trials at Rearsby is the new Auster Workmaster agricultural aircraft. Of traditional high-wing layout, it carries 90 gallons of spray fluid in a tank beside the pilot, an extra seat being provided for a passenger. The Lycoming 0-360-A engine of 180 h.p. driving a McCauley v.p. propeller gives it ample power; and slotted ailerons and balanced tail controls should provide good handling. Oversize tyres are fitted. Take-off run at 2,550 lb gross weight and cruising speed at 65 per cent power are respectively 180 yd and 88 m.p.h.

Britten-Norman spray gear will be provided by Crop Culture, Ltd., and this company has already ordered nine Workmasters. Five more are on order for a French associate concern, Ardic.

Mr. W. O. Manning

IT is with regret we record that Mr. William Oke Manning, a pioneer of flying-boat design and designer of the English Electric Wren, died in hospital at Farnham on March 2 at the age of 78.

He began aviation work in 1908, becoming chief designer at the Coventry Ordnance Works before the First World War and while there designing a biplane which took part in the Military Trials of 1912. At the outbreak of war he joined the Royal Navy and was concerned with the development of several R.N.A.S. aircraft; and in 1916 he became chief designer at the Phœnix Dynamo Co. in Bradford, where he was responsible for the development and construction of the famous F-class flying-boats for the Royal Navy.

When, in 1918, Phœnix became part of the English Electric organization he carried on as chief designer in the new company's aircraft department, going to Preston to supervise the carrying-out of an order for Porte flying-boats.

In early post-war years Manning introduced a number of ingenious features into military flying-boat design and also prepared designs for passenger-carrying aircraft—including the Eclectic, to carry 40 passengers at 100 m.p.h. for 800 miles, and the Pulex, for 50 passengers at 80 m.p.h. over 1,600 miles.

His last design for English Electric was the Wren. Three of these very neat machines were built, one taking part in the Light Aeroplane Trials at Lympne in 1923. One was rebuilt in 1956 (as recorded in *Flight* for January 25 last year, page 114), Manning assisting in the work as adviser; and he was present when it was formally handed over to the Shuttleworth Trust last September.

Nairobi's New Airport

INAUGURATION OF A £2.5m GATEWAY TO KENYA

FROM A. T. Pugh of "Flight" staff comes this first-hand report from Kenya about Embakasi Airport, opened last Sunday by the Governor, Sir Evelyn Baring. Regrettably the Queen Mother, who was to have performed the ceremony, could not do so owing to technical trouble which delayed her Qantas Super Constellation en route from Australia.

IT was a bitter disappointment to Kenya that the arrival of Her Majesty the Queen Mother at Embakasi should have had to be cancelled—owing to an engine failure en route from Australia—when the country waited *en fête* to greet her. In the event, with a ceremony for which so many had worked so hard, Nairobi's new airport was inaugurated on Sunday, March 9, by the Governor of Kenya, Sir Evelyn Baring.

For Kenya, Embakasi airport represents more than concrete and bitumen evidence of the country's stake, and firm belief, in civil aviation; it is a symbol also of economic resurrection from the dark days of an African rebellion that has been described by Sir Evelyn as "tantamount to civil war."

Few Europeans, it seems, appreciate the scale of the bloodshed in the colony. Over 12,000 of its inhabitants were *killed* (a figure quoted without distinction for colour or race, although the majority were, in fact, Mau Mau terrorists). The analogy of Embakasi airport rising from the ashes of rebellion comes to the mind when it is realized that the runway was almost entirely hand-built by large squads of Mau Mau undergoing "corrective" labour. And just as the achievement of a positive programme can supplant moral degeneration by firing the imagination (as was cynically indicated in the film *Bridge on the River Kwai*), so in Kenya many of the de-indoctrinated Mau Mau convicts asked to stay on—as convicts—until the task was completed.

It had originally been intended to open the airport before the "long rains" in August 1958. During these rains (there is also a short rainy season) the old international airport at Eastleigh can become unusable. Plans were drawn up in 1953, work started in January 1954, and by mid-1957 it was found possible to bring the operational date forward to mid-March 1958. An extra effort (still much in evidence two days before the opening) was made so that the airport could be opened by the Queen Mother.

The task was by no means straightforward, and many problems —largely of a civil engineering nature—had to be overcome before the runway could be built. The site chosen, on a great lava plain, is a pilot's and a controller's dream: eleven miles from the centre of Nairobi (the city's two other airports, Eastleigh and Nairobi West, are closer), its approaches are free from any obstruction for at least 17 miles in any direction. The nearest mountain ("high ground" would be a misnomer when Embakasi itself is 5,327ft a.m.s.l.) is 25 miles away, and 10 deg off the runway centre-line. Visibility rarely falls below this obstruction-distance in the clear air of the plains, and it may even be possible to see the summit of Mount Meru in Northern Tanganyika, about 140 miles away; both Kilimanjaro (115 n.m. away) and Mount Kenya can be clearly seen.

The runway is 10,000ft long between thresholds, and is sited roughly 06-24. Fortunately—because resources have been heavily strained to find the necessary £2,500,000 and assistance from the U.K. is still required—only one runway was needed, and the 06 approach will be used on 90 per cent of all occasions.

A basic strip 10,800ft long and 500ft wide was prepared for the 150ft-wide runway. There are 25ft shoulders each side; and consequently 150ft run-offs beyond the shoulders. After cambering, weak spots were reset, and finally paving machinery was used to lay the asphalt surface. The result is an engineering success of which the contractors are very proud; so accurate is the cambering that the wet surface of the runway dries out evenly each side of the centre-line. Physically, the great care taken in the engineering resulted in a load classification number of 100 being achieved, and the surface is capable of withstanding single wheel loads of 60,000 lb at tyre pressures of 200 lb/sq in. In bearing it is amply strong enough to accept Boeing 707s at gross weight, although 15,000ft rather than 10,000ft length is the probable all-weather length requirement. There is no physical limit to extending the paved length to this figure, but more definite plans for the operation of the big jets into Kenya would be required before such an increase was contemplated.

With this fine runway, and the natural advantages of good visibility, light winds and only very distant obstructions, landing aids can be of a simple nature. The existing *en route* beacon at Eastleigh will be preserved, and Embakasi is equipped with locator beacons, V.O.R., Murphy Mk 7 D.M.E., I.L.S., and two-channel Marconi V.D.F. The outer locator beacon, 3.9 n.m. from the threshold, is positioned in the Nairobi National Park, and is housed in a building that looks like a game ranger's hut. Installed in the briefing room in the terminal building is a weather radar receiver.

Installation of the aids presented quite a headache in the short time available and a flexible control system has been devised to be adaptable to all airport telecommunications. Special equipment could not be made available from the U.K. in time. Runway lighting is Calvert-type, made by G.E.C., with three bars on the 06 end only; there is a single bar for the 24 approach. In fact, very little night flying is scheduled in Kenya—of a recent sample of 700 flights out of Eastleigh, only 150 were made at night.

But the whole philosophy of Kenya's new airport is that it is built to cater for the expansion of air traffic that the colony is sure will come to East Africa. World traffic expansion and a steady traffic increase in Kenya points that way, and the colony was very anxious to avoid the under-estimates of Salisbury and Khartoum —let alone the more distant examples of London and Zurich and Idlewild and nearly everywhere else. So Kenya is one of the very few countries in the world that can boast a 1965-size airport with expansion capacity still in hand. Until June this year, the number of movements will not be greater than 600 a month, and after that, when all East African Airway's operations are centred at Embakasi, the number will still only be 1,000 a month. Even were Eastleigh to close as an R.A.F. airfield, only another 150 movements would be added. The peak capacity, on the other hand, is judged to be 20 movements an hour, and the maximum number of passengers about 1,200 per hour through airport buildings that have been designed for somewhere in the region of 300,000 passengers annually (with proportional daily peaks) by 1964.

The airport architect was strongly influenced by the design of Klöten, Zurich, in the planning and design of Embakasi, although similarities are by no means obvious. Both airports are arranged so that arrival passengers can see completely through the building; the minimum of signs is required. And although Embakasi has been designed to meet Nairobi's particular needs, both airports share a lightness and spaciousness that is extraordinarily refreshing. The fitting and colour schemes employed at Embakasi are absolutely first-class.

On each side of the Customs hall are some quadrangle gardens within the airport buildings. The smaller of these, adjacent to the arrivals channel, is intended to soothe nervous passengers. The garden on the other side of the hall has a pond stocked with golden carp and—so the story goes—small indigenous fish which appeared in rainwater pools during excavations for the runway.

(*Concluded on page 348*)

Kenyans were disappointed that the Queen Mother could not open the new airport at Embakasi, seen here with its typically fine visibility and clear approaches. The 10,000ft runway, with a L.C.N. of 100, is a big improvement on Eastleigh's 7,980ft murram runway, which in the rainy months is unsuitable for Britannias. Embakasi is eleven miles E.S.E. of Nairobi; elevation 5,327ft and "mean max." temperature 78.7 deg F.

THE FUTURE OF AIR FREIGHT

Some Basic Requirements Analysed

By FRANK ROBERTSON*

MUCH has been said and written to the effect that (a) in time, everything will travel by air, and (b) that nothing but mail and express parcels will ever travel by air (except in a war!). The writer is prompted to try and make an objective analysis of the position and to see whether any useful conclusions can be drawn.

Recent Air Freight Traffic. Reference to H.M. Government's Central Statistical Office digest reveals the interesting fact that during 1956-57 the average weekly freight traffic handled by the two British Airways Corporations totalled 1.65 million ton-miles.

Although it is obvious that a large proportion of this traffic was, in fact, carried in the holds of passenger aircraft, it is interesting to see how many average freight aircraft would have been employed to do the job. Let us assume that the mythical B.E.A. freighter has the performance of a Viscount 700 and that the B.O.A.C. machine is the equivalent of a Britannia 100.

The "Vistruck" could have been expected to carry four tons at 280 kt (assuming a two-thirds load-factor) and the "Britruck" to carry seven tons at 320 kt (two-thirds load-factor again).

If we assume an annual utilization for both aircraft of 2,500 hr, then the weekly capability of the pair of them is:—

$$\left(4 \times 280 \times \frac{2{,}500}{52}\right) + \left(7 \times 320 \times \frac{2{,}500}{52}\right) = 161{,}600 \text{ ton-miles}$$

From this simple sum, therefore, we can state that the existing freight traffic handled by the two Corporations could be dealt with by a fleet of ten short-range freighters equivalent to Viscounts and ten long-range freighters equivalent to Britannias—plus, of course, a few reserves.

It seems surprising that such a large fleet would be required and shows what a large quantity of freight must be carried in passenger-aircraft holds.

Ship and Rail Freight Traffic. The same statistical source tells us that, over the same period of time, British Railways handled an average weekly freight traffic of 400 million ton-miles, whilst the registered British seaports handled a weekly average of 4,000 million ton-miles. Figures for road traffic were not readily available.

The astonishing fact emerges that ten Viscounts plus ten Britannias can handle only rather less than a half of one per cent of the traffic carried by British Railways.

Suppose we imagine a B.E.A. freighter with the payload of a Beverley and the speed of a Viscount—16 tons at 280 kt (two-thirds L.F.)—and suppose we run it all day and all night and manage to get 4,000 hr utilization per year. How many should we need to equal B.R. freight traffic?

Here is the answer:—

$$\frac{400 \times 10^6}{16 \times 280 \times \frac{4{,}000}{52}} = 1{,}162 \text{ aircraft!}$$

If we imagine a big freighter aircraft about the size of a Tu-114 which could carry 30 tons at 400 kt, then to equal the traffic through the British ports we should need:—

$$\frac{4{,}000 \times 10^6}{30 \times 400 \times \frac{4{,}000}{52}} = 4{,}330 \text{ aircraft!}$$

Since B.O.A.C. and B.E.A. have a combined total fleet of less than 200 aircraft whose average payload and speed probably come out at five tons and 200 kt, what a vista for expansion lies ahead.

*Chief project engineer, Short Bros. and Harland, Ltd.

Cost of Freight Traffic. It is obvious that there must be some relationship between traffic generated and prices charged so we must now compare freight charges on rail, sea and air vehicles. It is not easy to establish average figures but recourse to various fare schedules and statistics have convinced the writer that a good first estimate can be written thus:—

	Air	Rail	Sea
Cost per ton-mile (sterling) ...	3s	3½d	½d

It is not easy to establish a significant law from these three sets of figures but, approximately, one could say that, if x=cost in pence/ton-n.m. and y=traffic in ton/n.m. per week, then:—

$$y = \frac{5{,}000}{\sqrt{x}}\, e^{-\sqrt{x}}$$

At all events it is clear that a reduction in air-freight costs from 3s to 1s 6d should cause a very large increase in traffic—probably about eight times the present figures. Let us take a look at the breakdown of aircraft costs to see what the chances are of such a reduction.

Of the 3s which is the average ton-mile charge for air freight, half of it is indirect costs or overheads: the cost of advertising, handling and loading freight, rents, rates and the general expenses of running an airline as opposed to an aeroplane.

The remaining 1s 6d can be divided into two portions, one representing the effects of first cost (amortization and interest), insurance, maintenance and repair, and the other representing fuel and oil and crews' salaries. Various other small items such as landing fees can usually be ignored when making broad estimates. These two portions are roughly in the proportion 14 to 4 respectively.

If we assume that indirect costs will remain equal to direct costs as the latter become smaller (not an unreasonable assumption, since total traffic can be expected to rise vigorously) then we have got to get our direct operating costs down to 9d/ton-mile.

The factors affecting direct operating costs are:—

(1) First cost per lb aircraft weight.
(2) Payload carried per lb aircraft weight.
(3) Block speed.
(4) Time spent flying per time available (utilization).
(5) Distance flown per lb fuel used.

If we use our own pet "short cut" operating cost formula (*R.Ae.S. Journal*, August 1957), these parameters are connected thus:—

$$\text{pence/ton-n.m. (two-thirds L.F.)} = \frac{1{,}000\, c\, u\, W}{V\, p\, P} + \frac{10{,}000\, F}{P\, R}$$

where

c = a factor connected with first cost
u = a factor connected with utilization
W = weight less fuel and payload in lb
V = mean cruising speed in knots T.A.S.
b = a factor correcting V to block speed
P = payload carried in lb
F = fuel carried in lb
R = equivalent still-air range corresponding to block distance covered.

For the sort of aeroplane which is today giving about 1s 6d/ton-mile costs these parameters are something like this:

c = 1 (representing about £8.6/lb empty weight)
u = 1.35 (representing about 2,000 hr per annum)
V = 240 kt
b = 0.825 (corresponding to an average stage of 500 n.m.)
W/P = about 2 (for 500-1,000 n.m. stages)
F/R = about 0.0004 (at 500-1,000 n.m. stages)

Let us now take each of these parameters in turn to see what the hopes are for reducing them.

Utilization. Something a little over 2,000 hr per year is the current figure for our airways Corporations. A good deal of the blame for this low figure must be placed at the door of "passenger appeal." People don't like flying at odd times—nor do other people like working an aeroplanes at odd times! However, there seems little reason why a freight service should not do better than this and, in the writer's opinion, a figure of 4,000 hr per annum should be achievable. This means that the factor u will drop to about 0.75.

Cruising and block speeds. If we assume that our new freighters are going to be turboprop-powered—a sensible assumption, since this is the cheapest form of air transport which we know how to build—then we should aim at a cruising speed of about 350-400 kt. On stages of 500 n.m. or so the block speed factor will drop to about 0.75.

". . . something to carry 25-30 tons at 300-350 kt. This could be powered with four turboprops in the 4,000-5,000 h.p. class . . ."

Weight and payload. The relationship between payload and empty weight is one which is sensitive to aircraft size as well as to structural and engineering efficiency. With an aeroplane having, say, four Tynes, there seems to be no reason why the factor W/P should not drop to about 1.7 for a short/medium-range aircraft. After all, the Douglas DC-6A achieves a W/P ratio of just under two with piston engines and carries its capacity payload over nearly 2,000 miles' equivalent still-air range.

Fuel, payload and range. Using modern turboprop engines and designing for a stage-length of 500-1,000 miles, the value for F/PR might reasonably be expected to approach 0.0003.

Effects of improved design upon cost. The improvements predicted will produce the following (using the short-cut formula):—

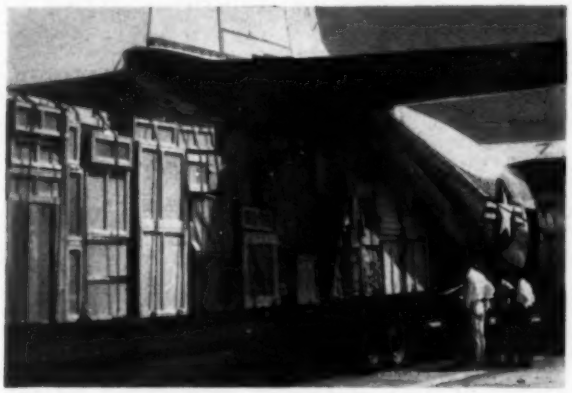
$$\frac{1{,}000 \times 1 \times 0.75 \times 1.7}{375 \times 0.75} + 10{,}000 \times 0.0003$$
$$= 4.54 + 3 = 7.54$$

which is less than half the direct operating cost of the existing aeroplane. Unfortunately, there is a snag.

First cost. We have so far assumed that our new freighter is going to cost the same £/lb as the existing aeroplane, i.e., £8.6/lb.

Statistics show us that this is more likely to be £12/lb for a new aeroplane of this class today and this raises our first cost factor to about 1.4 with the result that our direct operating cost is not 7½d but 9½d. However, this is not greatly in excess of our target of 9d and it is clear that freighter aircraft could be designed to halve existing costs and that *first cost is of prime importance.*

Are Special Freighters Warranted? The only aircraft in general commercial use today which was really designed for freight is the good old Bristol Freighter. In spite of its slow speed, this aircraft still operates quite economically and the reasons are that



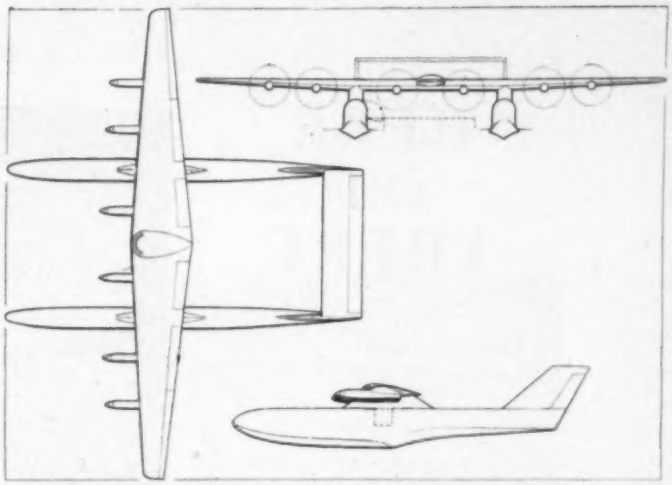
Full advantage of pallet loading, says the author, can be taken only if the aircraft has front or rear doors. The picture shows cargo entering the 4,300 cu ft freight hold of a C-130 Hercules.

it is cheap to buy and easy to load rapidly. It needn't spend much time on the ground. If we are going to achieve high annual utilizations for our freighters, it is clear that they must be very easy to load. This means that they have either to have a lot of large doors in the sides or top or they must be able to have the complete load rolled in at one end. In the writer's mind, there is not the slightest doubt that economical freight operation means end-loading and some form of pre-arranged stacking of the freight into a unit, either on a pallet or in some sort of container.

Since most passenger aircraft today have low wings (and therefore high floors) and since none of them has the sort of shape which lends itself to fitting large end-doors, it seems pretty clear that special aircraft are required. There are other contributory reasons. For instance, density. Passengers and their breathing space average out at 4½ lb/cu ft. Freight *averages* a lot more than this but may vary widely in individual cases. The passenger aeroplane, therefore, is always designed to approximately the same payload density whereas the freighter must be able to cope either with the large, awkward low-density load or with the small high-density load.

Then there is the question of design range. Passengers may well be prepared to pay for non-stop delivery over longish stages. When freighting, however, one cannot afford to give fuel a free ride (except in special cases). This factor normally means that a converted pasenger aircraft hasn't really enough space inside it for freight work and is probably intended for a longer range.

Effect of Size on Operating Cost. There seems little doubt that increase in aircraft size can go on reducing operating costs for some time to come. The ingenuity of engineers always seems



A suggested twin-hull flying-boat, designed to straddle a floating pier (dotted lines). The centre-section might carry a travelling hoist.

to beat the square-cube law and bigger structures are always easier to design because a smaller proportion of them is designed down to handling sizes.

One must remember that wing area will rise linearly (or thereabouts) with gross weight, whereas fuselage area will tend to rise with payload to the power of two-thirds. This means that total wetted area for a given weight will be less; and this fact, together with a steady increase in Reynolds Number, will result in a higher cruising lift/drag ratio.

A lot of things—crew, navigation equipment, etc., etc.—will remain virtually unchanged with increasing size on a freight aircraft, and all will tend to improve the empty/gross weight ratio. The item which will tend to work against the weight efficiency of the large aeroplane will probably be wing weight, but many palliatives may be found by ingenuity.

Utilization, of course, will tend to fall, since the bigger the aircraft, in general, the longer it takes to load and unload.

If ships are anything to go by, specific first cost *ought* to fall steadily with increased weight and size but, so far, aeroplanes show no sign of obeying this law.

All in all, it would seem that increasing size will result in steady, but not spectacular, improvements in operating costs. The thing that will really govern size is traffic; and since cost will certainly govern traffic and, to some extent, size governs cost, we have all the ingredients for a vicious circle.

Possible Freighter Designs. The Bristol Freighter has already been mentioned; with its five-ton payload and 140-kt cruising speed, it is the only British freighter in regular operation. The Blackburn Beverley has so far not appeared in civil use but could carry up to about 18 tons at 155 kt.

Coming along soon is the Armstrong Whitworth Freighter Coach which can be expected to take 12 tons at 240 kt or thereabouts. This latter aircraft ought to have direct operating costs at two-thirds load-factor and with average utilization of somewhere about 1s 1d or 1s 2d per ton/n.m., plus its excellent rapid-loading facilities, should do a lot to open up the freight market.

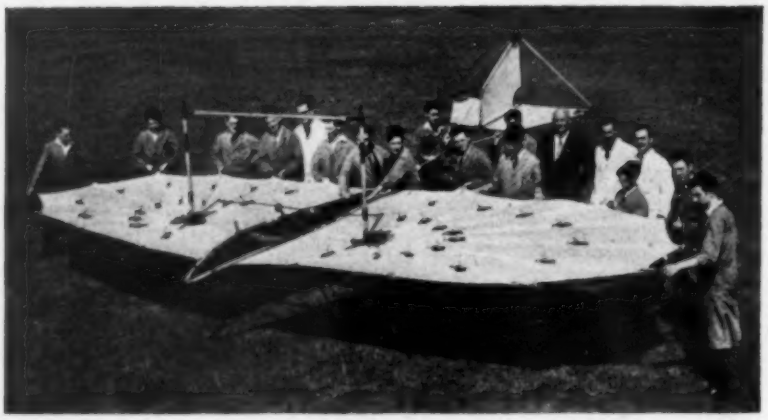
The next design for which there ought to be a market in a few years' time is something to carry 25-30 tons at 300-350 kt. This could be powered with four turboprops in the 4,000-5,000 h.p. class and should bring direct costs down to about 11d. Development with improved engines would result eventually in this aircraft reaching about 9d/ton-n.m. with two-thirds load-factor over short/medium stages. Such a machine could reach the 150-ton a.u.w. class during its development life and it would seem open to doubt whether it is sensible to go much further than this with runway-operated aircraft.

Landplane weights may well rise a lot higher than this with VTOL, where the heavily reinforced ground surface needs only to be limited in area, but the economics of VTOL are likely to stay well out of the freight traffic bracket for a long time to come.

It would never surprise the writer if a sudden change of heart brought back the very large seaplane for freight (and possibly passenger) work. If this were to happen, then the aircraft would probably be twin-hulled, in order to optimize wing weight, and would be docked over a single central pier. It is not difficult to envisage such an aircraft, carrying perhaps 150 tons of freight and 20 or 30 casual travellers, powered by large turbine-driven propellers. It is possible that the turbines might be nuclear powered, but the probability is that such will be used on the ground to manufacture turbine fuels very cheaply.

Such large aircraft as this, however, are very unlikely to be built until the volume of air freight traffic has been raised by a very considerable amount above its present-day level and then only if it can be shown that they will reduce operating costs.

HERE AND THERE



FULL-SCALE REPLICA: Armstrong Whitworth Aircraft apprentices with the replica they have built of the glider in which Percy Sinclair Pilcher, who in 1895 made the first controlled flight over Britain, was fatally injured in 1899. Seen at Baginton (with Mr. Alan Jenkin, apprentices' supervisor, in the group around it), the glider is to be presented by the R.Ae.S. on March 26 to Lord Braye at his home, Stanford Hall, near Rugby, where Pilcher used to fly and where a museum is being set up. This will be open to the public from Easter Sunday.

SHAPE Air Deputy

APPOINTED Air Deputy to the Supreme Allied Commander Europe, Gen. Leon Johnson of the U.S.A.F. takes up this newly revived post on April 1. He led the attack made by Liberators of the Ninth Army Air Force from Benghazi against the Ploesti oil refineries in August 1943, and has recently been serving on the NATO Standing Group in Washington.

NATO Air Exhibition

AN aviation exhibition is to be opened at Soesterberg Royal Netherlands Air Force base on July 5—coinciding with the NATO air display there—and will remain open for a fortnight.

Aircraft Industry Strength

IN December last year, according to Ministry of Labour statistics, there were 257,000 people employed in "the manufacture and repair" of aircraft. The total for December 1956 was 264,000.

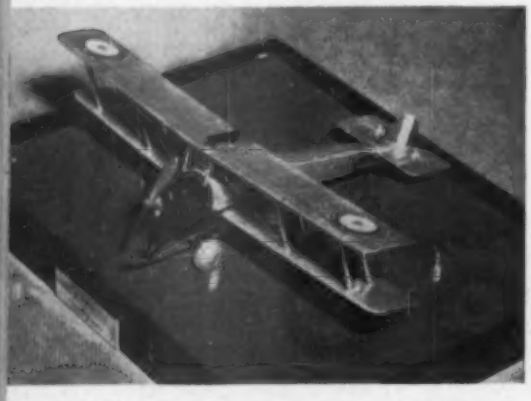
F.A.A. "At Homes"

DURING this summer the following Royal Naval Air Stations will be open to the public on the dates given (all Saturdays): Ford, June 21; Abbotsinch, June 28; Eglinton and Culdrose, July 19; Lossiemouth, July 26; Brawdy, August 2; Yeovilton and Lee-on-Solent, August 9.

High-speed Flight

SECOND of three colour films being made by the Shell Film Unit on high-speed flight, *Transonic Flight* was given a preliminary showing in London last week. It deals with problems arising within the transonic speed range (particularly the shock stall) and methods adopted to lessen the effect of the stall and make flight smoother at lower transonic speeds. The film lasts about 35 minutes and colour Schlieren photography is effectively used to depict the behaviour of an aerofoil at speeds around Mach 1. The third film in this series, *Supersonic Flight*, is now in course of production.

SMALL-SCALE REPLICA: One of these splendid little models of the Avro 504—the gift of the British Petroleum Co., Ltd.—was presented to each member of the Avro 504 Club at the seventh reunion dinner, reported in "Flight" last week.



HELICOPTERS TODAY

NEXT week's issue of *Flight*, dated March 21, will be an enlarged special number devoted to the world's helicopters. All current types will be reviewed, and a special article will survey helicopter progress and forecast future possibilities. Our regular features will be included.

Rolls-Royce Prizes

TWENTY awards, known as Hives Prizes and worth a total of £1,000, are to be made annually to trade and craft apprentices in Rolls-Royce factories throughout Britain. Each will be worth £50—half in cash and the remainder to be spent on books, tools, a course of study or some other approved purpose.

Far East Market

JAPANESE aircraft and engine manufacturers have recently been visited by Mr. F. T. Hinkley (general manager, sales and service, Rolls-Royce, Ltd.) to investigate their needs for engines for types of aircraft now on the drawing-board. The manufacturers, who expect to start production of airliners for internal and Far East routes within the next few years, have expressed a preference for Rolls-Royce powerplants.

Light Polish Jet

A POLISH design for a two-seater jet sports aircraft is reported to be well advanced. It will be powered by an engine of 400 kg (880 lb) thrust and is intended for use by "experienced sports pilots."

Kolibries for Israel

IT is learned that the first export order for the small Kolibrie ramjet helicopter is from Israel. A company called Wings of Israel Air Service has ordered three for agricultural work. It is stated that the price of the Kolibrie is "one-third that of a piston-engined helicopter having the same capacity." During April the Kolibrie will be demonstrated in West Germany. Two of the four ordered by the Dutch Aerocoop agricultural concern have been delivered. The same company operates a Djinn and four Bell 47Js.

Thor Progress

TWELFTH of the XSM-75 development Thor IRBMs to be fired from Patrick A.F.B., the round launched on February 28 was the first to be fitted with the definitive blunt nose-cone and re-entry body. The U.S. Air Force last week stated that the SM-75 weapon system should be "combat-ready" by June.

Starfighters for Germany?

FOLLOWING his four-week tour of U.S.A.F. bases it is reported in Washington that Lt-Gen. Kammhuber, C-in-C. of the West German Air Force, will recommend that the Ministry of Defence should buy Lockheed F-104 Starfighters. He said he considered these aircraft "the best supersonic fighters in the world."

Autogiro Accident

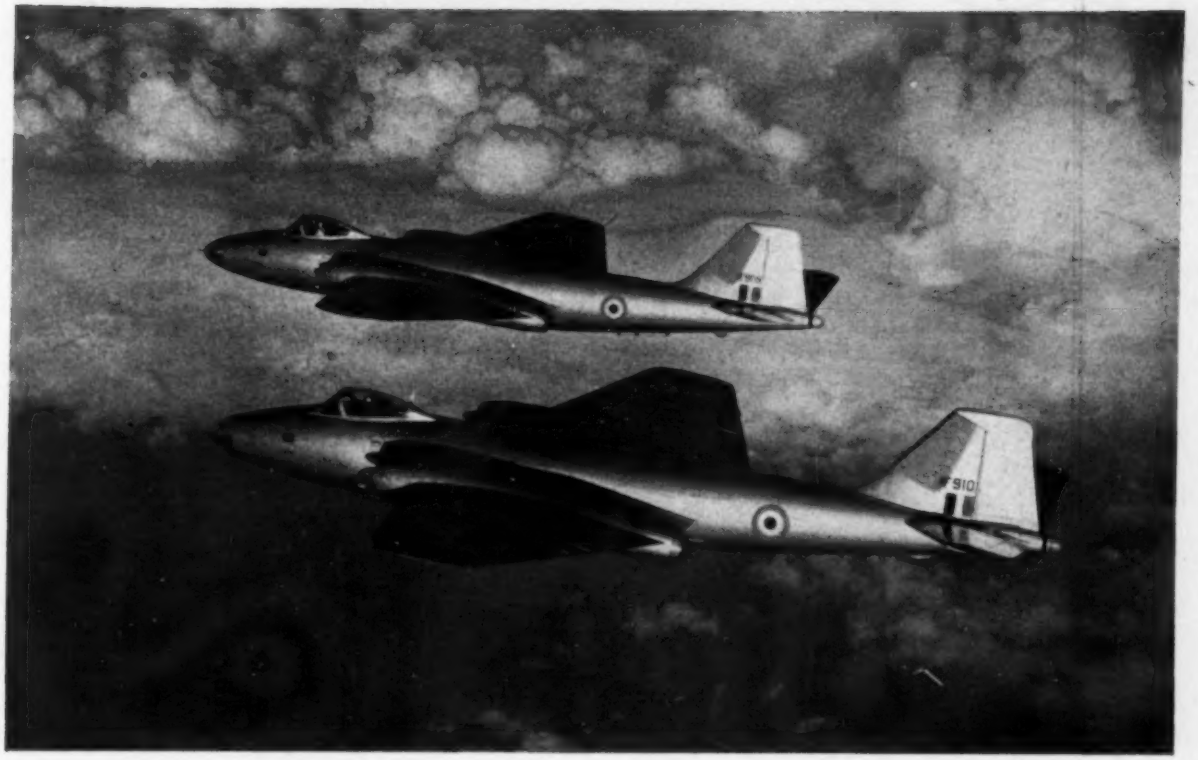
ONE of the only two Autogiros left in Britain—G-AHTZ—crashed, caught fire and was severely damaged at Elmdon Airport, Birmingham, on March 4. The pilot, Capt. G. Jillings—who was seriously injured—was completing the five hours' solo flying necessary to qualify for a passenger-carrying endorsement when the accident occurred. The aircraft was owned by Rota Towels, Ltd.

Irish A.S.R. Service

AT a symposium held recently in Dublin by the Maritime Institute of Ireland the setting-up of a helicopter air-sea rescue service was considered. Capt. J. C. Kelly-Rodgers of Aer Lingus said that the cost of helicopters would be about £28,000 each, with a further outlay of £15,000 for spares and maintenance for three machines. Lt-Cdr. H. H. Harvey of the R.N.L.I. said that since last October ten accidents had occurred in which helicopters could have given assistance to lifeboats.

Happy Miles

PUBLISHED today (March 14), this year's Spring and Touring Number of our associated journal *The Autocar* contains an abundance of practical advice on routes, holiday resorts, costs at home and abroad, touring, caravans and camping.



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This standard of achievement is typical of the whole range of de Havilland air-conditioning equipment.

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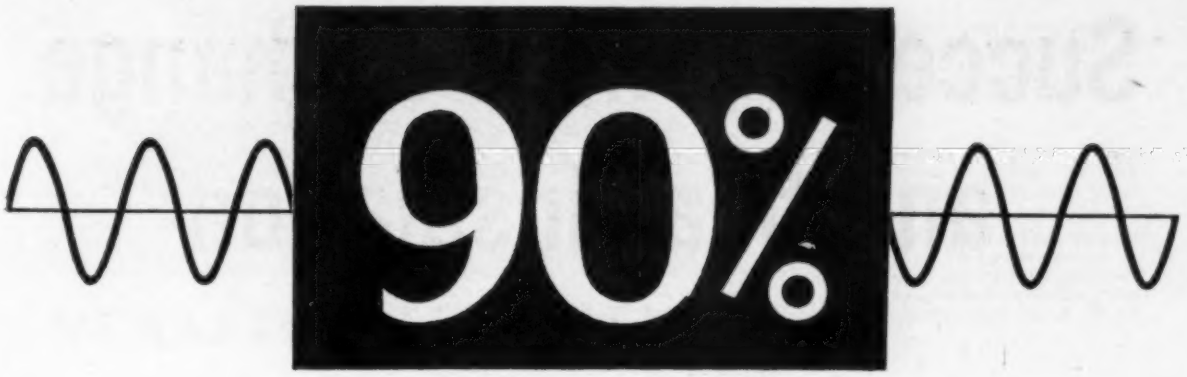

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DE HAVILLAND ALTERNATORS

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We are now introducing Sealed Blankets for Civil Aircraft

Differing from earlier Furies in many respects, the North American FJ-4B is equipped for automatic toss-bombing with atomic weapons. Powerplant is a Wright J65 (Sapphire).

AIRCRAFT INTELLIGENCE

U.S.A.

Grumman A2F. As yet unnamed, the A2F-1 is now in the engineering-design stage at Bethpage, and the prototype should fly in about one year's time. Intended for tactical naval attack operations, the A2F will be powered by an 8,000-lb-thrust Pratt and Whitney J52, will have a crew of two and will be capable of operation from all U.S. Navy carriers.

North American FJ-4. Limited production is continuing at Columbus on the FJ-4B Fury multi-purpose attack aircraft for the U.S. Navy (photograph above). What will probably be the final version is the FJ-4F, for which North American Aviation's Rocketdyne Division have developed a single-barrel H.T.P./JP-4 rocket motor for combat boost. This is the first mixed-power aircraft to go into production in the Western world.

North American A3J-1. One of the most important new aircraft under development in the U.S.A., the A3J is to be the standard long-range piloted megaton-delivery system of the U.S. Navy. Capable of operation only from the *Forrestal*-class carriers, the aircraft will have side-by-side seats for a crew of two and will be powered by a pair of afterburning G.E. J79 engines mounted at the rear. Maximum speed will be Mach 2. A land-based version, dubbed the "Retaliator," is being evaluated by the U.S.A.F.

Kaman H-43. The standard "fire crash rescue" helicopter of the U.S. Air Force, a definitive contract for about $10m is being negotiated for an initial batch of 130; two will be assigned to each S.A.C. base. The first version, the H-43A, will have a single Pratt and Whitney R-1340 Wasp engine, but the H-43B will have a Lycoming T53 turboshaft engine.

France

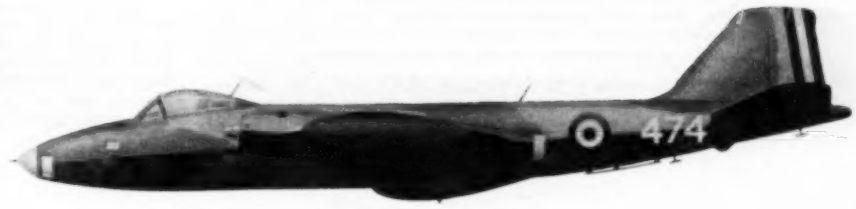
Bréguet 940. The maiden flight of this exceedingly interesting STOL aircraft is scheduled for a date in April. The prototype will be a flying test-bed with four synchronized Turboméca Turmo turboprops. A French report states that the operational version, the Bréguet 941, is "presently under intensive study." The report continues: "The United States . . . with whom a co-operation agreement has recently been signed, through the agency of Piasecki Aircraft, has shown interest."

Bréguet Deux Ponts. Details of the flight to America of the Bréguet Deux Ponts four-engined transport have been given. The tour, which was organized at very short notice, occupied 108 hours 48 minutes of flight and more than 18 hours of demonstration over a period of 35 days. A total of 495 persons flew aboard, including representatives of 28 American transport companies and officers of various South American air forces. It is stated that 1,500 spare parts were carried but not a single one was required.

Sud-Aviation Alouette II. Five Alouette II helicopters are being despatched to Republic Aviation in a K.L.M. freighter. The delivery follows seven aircraft already supplied, five having been despatched on February 15.

ENGLISH ELECTRIC CANBERRA B(I).8
(Peruvian Air Force)
(Two Rolls-Royce Avon)

Span	63ft 11¼in
Length	65ft 6in



THE CANBERRA STORY

Design and Development of a Very Famous Aeroplane

"THE Canberras in the Second Tactical Air Force and in Bomber Command are being given a nuclear capacity"—so says the Memorandum published with this year's Air Estimates. It is now fourteen years since the first design thoughts were given to this aeroplane, and nine years since it first flew. Quite clearly the Canberra is not "played out," for it continues in full production for both the Royal Air Force and for overseas customers, and even its earliest versions are still in front-line service in all parts of the world. It is, in fact, a very remarkable machine.

More than most British jet aircraft, the Canberra has had, and still has, a classic development life—or in more expressive jargon, "stretch." The Mk 9 photographic-reconnaissance aircraft, with its new wing and advanced Rolls-Royce Avons, will, we may reasonably expect, have a higher over-target altitude than any other Western aircraft of its type; and even the existing versions are quite capable of setting new world records. Last month a Canberra Trainer set a new point-to-point speed record by flying the 2,058 miles from Washington, D.C., to Caracas, Venezuela, in four hours eleven minutes, while six months ago, on August 28, 1957, a B.Mk 2, fitted with a Napier Double Scorpion rocket engine, raised the world altitude record for aeroplanes to 70,310ft (and on several occasions has been higher).

This, then, is the measure of English Electric's first post-war aeroplane: in service with eight countries, produced in three, and current holder of 20 international class records—which is more than any other jet aeroplane in the world.

It all began in 1944, when Mr. W. E. W. Petter investigated a proposal of Sir Ralph Sorley (then controller of R. and D. at the Ministry of Aircraft Production) for a jet-propelled aircraft to succeed the Whirlwind and Typhoon in the low-level fighter/bomber rôle.* When Mr. Petter joined the English Electric company in 1944, he found there virtually no design organization capable of undertaking a new aircraft project. Throughout the war—in fact, for a year before it began—the company had been concerned only with the manufacture of other people's aircraft (770 Hampdens, 2,250 Halifaxes—and later, almost 1,400 Vampires). Under Mr. Petter's leadership the small design team which had dealt with modifications to these aircraft was steadily built up and, with very few people and without any of the facilities normally available to a design team, they began the investigation of various configurations to satisfy the new requirement of a high-altitude bomber (it was not until much later that the ground-attack rôle for the Canberra was to be revived). The approved policy was, first, to make use of all the technical data which could be reasonably well established at that time and, second, to "push" the design to the limit of this knowledge.

By June 1945 the design had evolved into a mid-wing monoplane, powered by a single, very large turbojet, and crewed by a pilot and navigator (with alternative seating positions, either side-by-side or back-to-back). Even at this embryonic stage the aircraft bore a resemblance to the now familiar Canberra form. There was the long fuselage of circular section, the businesslike-looking tailplane and fin, and the large one-piece elliptical cockpit canopy.

A particularly interesting difference between this early design and the Canberra proper lay in the powerplant—just one giant engine. "After some consideration with Rolls-Royce," the brochure on this aircraft states, "the conclusion was reached that an engine of 66 inches in diameter appeared to be a feasible proposition." It was to be a two-stage centrifugal engine, which, "with reasonable certainty" could produce the necessary static thrust of at least 12,000 lb. This single unit was decided upon after a careful study had been made of the other engines then available. The aircraft was obviously going to be in the 40,000-lb class, and, to obtain the required cruising speed of 500 m.p.h. at 35,000 to 40,000ft, it was clear that three engines of any existing type would be needed. The diameter of each of these was about 48in, so that—assuming fuselage-mounted engines—the cross-sectional area of the body would have been appreciably in excess of that required for the crew and load. Even when these engines had been developed it was still considered that two would have been needed. Some saving of frontal area might have been achieved by staggering the engines one behind the other (shades of the P.1's propulsion system?) and considerable attention was given to this idea, but the fuselage still came out much fatter than that required for a single 12,000-lb engine. With a single engine there were, too, very considerable weight savings in the long jet-pipes and the fuel and control systems.

May 1949 at Warton, Lancs: the shiny blue A.1 is towed out of the hangar for the first time, with a ground-running intake on.

Having decided to use a single engine, it became feasible to employ a fuselage of circular section; this fitted in well with the design of the pressure-cabin at the front, and followed on naturally to the circular engine and tailpipe. The circular section was also relatively easy to design and produce, and it lent itself to low drag at the wing and tail intersections. This balanced layout bestowed a useful load-carrying section between the pressure cabin and the powerplant. The top half of this section was logically devoted to fuel tanks and the lower half to bombs, in one or other of the following combinations: $6 \times 1{,}000$ lb, $1 \times 4{,}000$ lb and $2 \times 1{,}000$ lb or 8×500 lb. A second fuel tank was situated in the rear fuselage around the jet-pipe to avoid any c.g. change when fuel was used. Thus all the fuel was located in the fuselage, leaving a considerable space in the wing leading-edge for further fuel during the development life of the aircraft. (This was, in fact, actually done: the sole Mk 5 was the first to have integral wing tanks, followed by the B.6, PR.7, B.8 and PR.9 models of much later vintage.)

This, then, was the first "crystallized" design—or rather partly crystallized, for a month later a new brochure came out, showing the aircraft with two engines buried in the wing-roots. It was, again quoting the brochure, the rapid development of jet power units that led the English Electric team to re-examine its design and convert it into "an improved proposal of the same general size and type." The new engines were two axial Rolls-Royce AJ.65s, forerunners of the Avon. These were of considerably smaller frontal area than the giant centrifugal and could thus be almost completely buried in the wing root. Admittedly the wing profile had to be swollen to 15 per cent at the root, but the intakes were so designed that the effective thickness of the wing nowhere exceeded 12 per cent. The main undercarriage units were moved nearer to the centre-line of the aircraft and so benefited from the advantage of the extra wing depth.

This period provides a classic example of design-evolution, and was an essential step towards the final Canberra configuration. In particular, the advantages of two engines were recognized—albeit slightly grudgingly, for the brochure says that, although the revised design had twin-engine reliability, it did not altogether concede that such a precaution was necessary with jet engines! This powerplant disposition also provided greater flexibility for

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**From a lecture by F. D. Crowe, B.Sc., A.F.R.Ae.S., Chief Designer (Canberra), Aircraft Division, The English Electric Company, Ltd., given before the Belfast Association of Engineers on February 26, 1958.*

installing later types of engine—an advantage which has paid handsome dividends, for Canberras have done sterling work as flying test-beds for almost every new British jet engine (and rocket motor).

Removing the engine from the fuselage allowed Mr. Petter's team to give the aircraft a bomb bay of substantially increased overall dimensions which could carry many combinations of bombs, including a single 8,000-pounder. The more efficient axial engines had a lower specific fuel consumption, and thus the tankage was slightly reduced and the cells above the bomb bay somewhat simplified in design. The elimination of the fuselage jet-pipe made possible a simpler and lighter tailplane and also saved considerable weight aft. In turn, this led to a reduction in the length of the front fuselage, without any reduction in the available stowage space as the former engine bay became available for bomb load and fuel (as the drawings show).

Data about high-subsonic aerodynamics was obtained from Germany, and an alternative layout for the twin-engined scheme was planned with a sweep-angle of 30 deg on the wings. This would have raised the critical speed by about 35 m.p.h. at 40,000ft and, owing to the more forward position occupied by the engines and heavy wing roots, a still more compact fuselage became possible. But there were also disadvantages, and to this day the idea of a swept-wing Canberra has never again been seriously considered. It must be remembered that in 1945 tip stalling was causing trouble on swept tailless designs (the D.H. 108 and A.W.52) and sweepback invariably increases wing structure weight. In any case, the maximum speed envisaged was not seriously affected by compressibility, owing to the modest total thrust.

Compared with the single-engined scheme, the gross weight of the twin-engined (straight-winged) aeroplane was reduced by more than ten per cent, to under 40,000 lb. This was due to the reduction in aggregate powerplant weight, lower fuel consumption and the improvement in fuselage design and consequent structural savings. The wing area was reduced from 1,040 to 950 sq ft, without increasing the wing loading, and the aspect ratio was correspondingly reduced from 5.4 to 4.9. There were also some detail design changes in the pressure cabin. The navigator was placed behind the pilot, facing forward and connected with his colleague by a gangway on the starboard side. This gangway was later extended to the nose to provide a stand-by prone visual bombing position when it was found that suitable blind-bombing radar was not immediately forthcoming. The proposed radar scanner was to be housed entirely within the lower half of the nose and the twin-wheel nose gear was moved back and arranged to retract vertically behind the pressure bulkhead.

Finally, in the autumn of 1945 the first real Canberra design came about. A brochure was submitted to the Ministry of Supply to meet the B.3/45 specification, and on January 7, 1946, a contract for four prototype English Electric A.1 aircraft, as they were then known, were ordered (the name Canberra was applied after the prototype flew). At about this time Mr. Petter and his strengthened design and development team moved from their converted garage home in Corporation Street, Preston, to the R.A.F. aerodrome at Warton, eight miles west of Preston on the muddy banks of the River Ribble. During the war Warton had been occupied by the United States Army Air Force, and to some small extent it was a suitable habitation for a design staff. There was, for instance, a central-heating system so efficient that it eventually had to be taken out of service to provide more "British" working conditions.

Details of new aircraft being designed and developed in Britain and the U.S.A. began to reach the outside world, but work at Warton managed to go steadily ahead in great secrecy. Nevertheless, a year or two later, well before the first flight of the Canberra, it became an open secret—at least in the British industry—that the English Electric Co. were making the first aircraft of their own for more than twenty years.

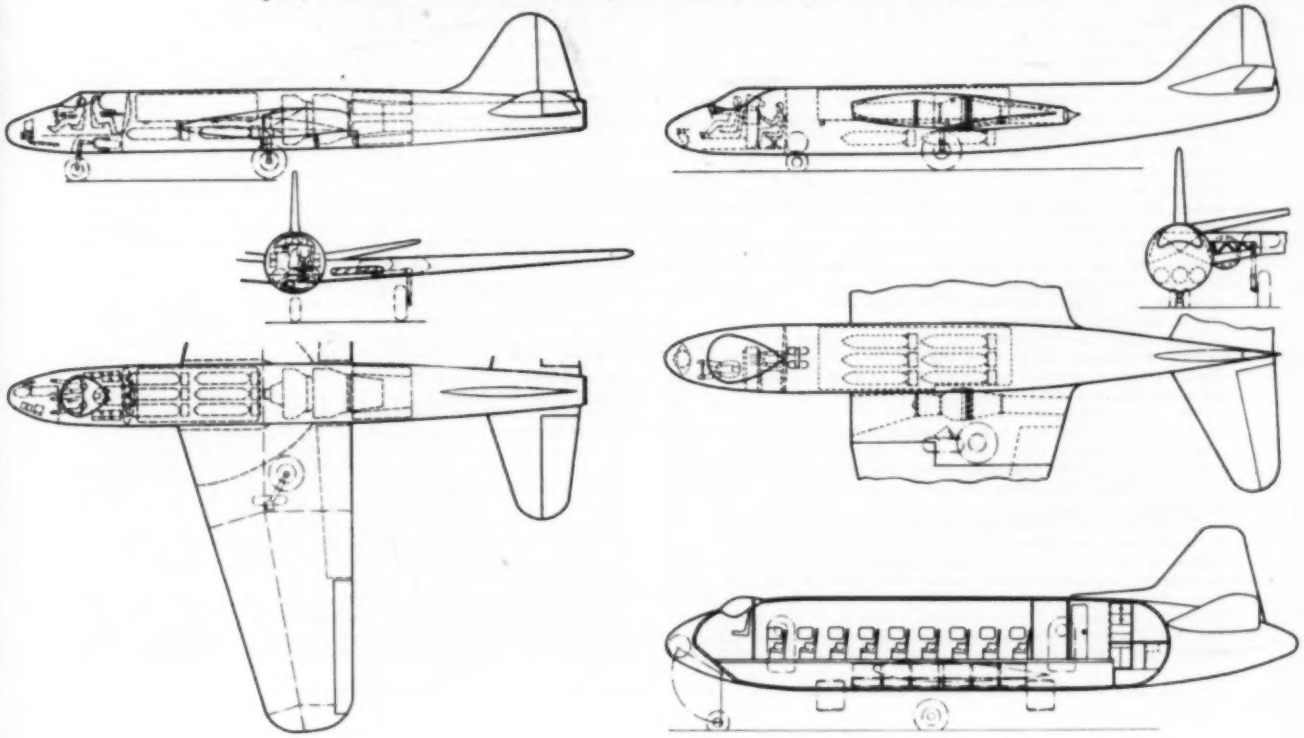
There have been many suggestions that the Canberra should be turned into a civil aircraft, and in this context a study made in October 1946 is worth recalling. This described a 34-passenger airliner for stage-lengths of between 490 and 930 statute miles, depending on the operating altitude, with a maximum range of 1,600 miles with 16 passengers. This interesting design was a straightforward development of the A.1 project with an enlarged fuselage giving an interior diameter of 10ft.

The cabin was pressurized and soundproofed and entirely unbroken by structure. The seats were arranged in orthodox style in pairs on either side of the gangway. Baggage was to be stored under the floor within the pressure hull—this for structural convenience—in a space estimated at 320 cu ft. In order to take full advantage of this freight hold, it was proposed to load baggage and cargo on to a series of trays which were then to be pushed along the length of the freight compartment on tracks. This allowed the size of the compartment door to be kept to a minimum, and it was suggested that baggage should be pre-loaded on to special trays immediately on arrival at the airport, so that embarkation time could be kept as short as possible (shades of the Electra!).

This civil version was to have had two Rolls-Royce AJ.65s, each of 6,500 lb-thrust, boosted by 1,000 lb for take off. Later development was envisaged by installing more powerful engines. The original AJ.65s would have given the aircraft a cruising speed of about 450 m.p.h., which would have put the aircraft in the same performance bracket as the early Comets, though over shorter ranges.

This study was typical of the investigations which are always made by companies which have a good basic aircraft design to play with. That it was never proceeded with was due to several factors—not the least of which was that a great deal of English Electric's energies were then being devoted to the development

Below are projects dating from 1945 and 1946. Left is the original, single-engined bomber design. On the right is the next stage, with twin axial engines, and below the latter is the 34-passenger transport, which was planned in the autumn of 1946.



For four years the Canberra B.2 was our only jet bomber. This picture was taken in Lincolnshire in 1952, when undersides were blue.

THE CANBERRA STORY . . .

of the military Canberra, and even in those early days the company's thoughts were inexorably turning towards aircraft of far higher performance. (It is interesting to note that English Electric did several civil design-studies soon after the first World War, one of which was for an eight-engined flying-boat with a range of 1,600 miles carrying 50 passengers. It shows, too, that the company's design thoughts are not, and never have been, exclusively centred on military work.)

Much specialized equipment was needed for ground-testing the Canberra: mechanical test facilities of all kinds, electronic computers and, of course, wind tunnels. That this equipment was imperative was quickly recognized by the board of directors of English Electric and substantial sums of money were allocated for it. This was really the beginning of the great range of equipment and facilities which the company now possesses, and which is today enabling them to conduct invaluable development into many facets of very-high-performance flight. But it was not just the equipment which enabled them to produce in the Canberra an advanced flying machine. The other essential ingredient of the design team was the wit to interpret and apply the information which this new equipment provided.

It was at once foreseen that a tremendous range of test equipment would be needed to carry through the long Canberra development programme. Three tunnels were built: a 9ft × 7ft low-speed unit, a jet-induced high-speed tunnel and a water tunnel. The low-speed tunnel became operative in May 1948, the high-speed one two months later and the water tunnel in March 1949. These played a major part in the Canberra programme, but they were not the only equipment provided to aid the design team. There was a large structural test frame, in which a complete Canberra wing was installed, and which later tested a complete P.1A airframe to destruction. There was also a hydraulic rig to prove the endurance of the aircraft's hydraulics, and a whole range of other equipment. Nearly all the design and construction of these facilities was done by the English Electric Aircraft Division, with the help of other departments of the company. The jet tunnel was capable of dealing with all the speeds called for by the Canberra, but it was later superseded by a supersonic tunnel, with a top speed of Mach 1.6, for initial P.1 "flying."

The first A.1 Canberra prototype made its maiden flight on what some superstitious people might have thought to be an inauspicious day: Friday, May 13, 1949. Already ordered "off the drawing board" many months previously the aircraft was already in the early stages of quantity production when this maiden flight took place and, consequently, it was only 18 months afterwards that the Canberra B.2 was in squadron service with 101 Squadron of R.A.F. Bomber Command at Binbrook, Lincolnshire.

At the Society of British Aircraft Constructors' banquet at the Dorchester Hotel, London, on September 6, 1949, Lord Tedder referred to the Canberra as a "good looking youngster" which would soon be taking the place of the Lancasters, Stirlings, Halifaxes and Lincolns. He reminded his audience that, even at the end of the war, Germany was producing more fighters than Britain and the U.S.A. together; and therefore the ability of Britain to produce a modern bomber was important. It was, he said, on the "punch forecast by the Canberra" that one's mind was at that time concentrated.

Even before the first Canberra flew, the process of "stretching" began. The three Mk 1s were true prototypes, one having Rolls-Royce Nene engines as an insurance against the failure, which certainly did not occur (see *Flight*, December 16, 1955), of the Avon. The non-appearance of certain essential equipment led immediately to the B.2, with its visual bombing position in the nose and a crew of three. The extra man was the bomb aimer, who also assisted the navigator in his challenging task of directing the route of a bomber flying twice as fast as the previous generation of aircraft.

Production of a substantial number of B.2 bombers was well in hand when the Korean War began in the summer of 1950. In common with certain other British aircraft the Canberra was re-ordered in great quantity, and to speed production three other large firms were asked to tool up and manufacture B.2s for Bomber Command. These companies were A. V. Roe at Chadderton and Woodford, Handley Page at Cricklewood and Radlett and Short and Harland at Queen's Island, Belfast (thus the wheel turned full circle, English Electric having previously only built aircraft for other companies). Avro and H.P. each delivered 75 B.2s, but Shorts went on to make the B.6 and B(I).8 (described later) and have already delivered well over 100 machines. They are now responsible for the most advanced Canberra, the PR.9.

From the B.2 came the PR.3, which was the first purely photographic aircraft ever to be designed for the R.A.F. The fuselage was lengthened by 14in to accommodate a forward camera bay and cameras were installed to give a complete mosaic pattern by day or night. Fuel capacity was increased by using part of the original bomb bay for tankage, a much smaller bay being needed in the P.R. version for photographic flares. The crew was reduced from three to two, and the bombsight was replaced by a photographic sight.

Also evolved from the B.2 was the trainer Canberra, the T.4. Six years ago the R.A.F. needed this trainer because they were converting to the Canberra National Service pilots with very little experience, and a dual aircraft was wanted for check-flights. Again this was a comparatively straightforward, if major, modification. The cockpit was laid out purely for pilot training, with side-by-side dual controls. The pupil sat in the port seat with the instructor to starboard in a seat which slid back to admit all three crew-members. No lightweight ejection seats were then available and so the two pilots had fixed seats, but the navigator sitting behind on the port side retained a conventional ejection seat.

Development of the Avon engine went on concurrently with the development of the Canberra airframe, and the next production mark of the aircraft, the B.6, was fitted with a rather more powerful version. In addition integral wing tanks were incorporated in this variant; they were first fitted to the solitary B.5, which was intended as a target-marking machine but was quickly superseded by the B.6. In parallel came the PR.7, the photographic version bearing the same relationship to the B.6 as the PR.3 did to the B.2.

The next advance was a radical one—adapting the Canberra for the ground-attack rôle while still retaining its potency as a high-altitude strategic weapon. This was to be a development of the B.6 but with a removable gunpack containing four 20 mm cannon and a vast amount of ammunition in the bomb bay, together with a reduced bombload, and—most important—a new nose and redesigned crew compartment. This was the "new look" B(I).8 Canberra (I = interdictor) with the pilot sitting farther back from the nose beneath a fighter-type canopy on the port side of the fuselage, and the navigator sitting below and ahead of him in a swivel chair. This new arrangement gave the pilot greatly increased visibility forward, downward and behind; he could, in fact, see the port tailplane over his right shoulder. Additional stores could be carried on underwing pylons and a camera pack could be hoisted into the bomb bay to make the aircraft a true all-rounder, fit for ground attack, high-altitude bombing or high- and low-altitude reconnaissance.

From 1951 Bomber Command was progressively re-equipped with the new jets, and on August 31 of that year the Canberra set the first of its 20 official world records. On that day Mr. R. P. Beamont, chief test pilot of English Electric, with a company navigator, Mr. D. A. Watson, and Mr. R. H. T. Ryland of Marconi's, flew from Aldergrove, Northern Ireland, non-stop to Gander, Newfoundland in four hours 18 minutes 24.4 seconds at an average speed of 481.12 m.p.h. The Canberra was being ferried across to the Glenn L. Martin Company at Baltimore, who had just reached a licence agreement with English Electric to manufacture the Canberra for the U.S. Air Force. This agreement was signed on April 19, 1951, and Martin effected a swift re-engineering and then tooled for rapid production. The first Martin-built Canberra flew on July 20, 1953. With the U.S.A.F. designation of B-57A the aircraft was basically an "Americanized" B.2.

Production of Martin B-57s has now almost finished; nearly 400 were made and a substantial dollar sum was earned by English Electric as a result. The B-57 differed in many ways from the Canberra, although externally it closely resembled its forebear. The engines were J65s (Armstrong Siddeley Sapphires made under licence by Curtiss Wright). Only a relatively small number of B-57s and B-57As (counterparts to the B.2 and PR.3 respectively) were built, for the major part of the U.S.A.F. order was for B-57Bs, which correspond broadly to the British Canberra B(I).8 high-altitude bomber and ground-attack aircraft. The nose of the B-57B was largely redesigned, and the crew of two sat in tandem under a single clamshell cockpit canopy. The bomb bay in all the American versions was of the rotary type (*Flight*, August 14, 1953). After the B-57B came the B-57C dual-control operational trainer, the B-57D high-altitude J57-powered version and the popular and widely used B-57E target tug.

Even before the Canberra was in R.A.F. service the Australian Government had taken a keen interest in the design, and English Electric signed a licence agreement with the Australian Government for the production of Canberras for the R.A.A.F. at the

Fairey flies the first Vertical Take-off Airliner

Adding achievement to achievement, Fairey Aviation have now built potentially the most important transport aeroplane in the world, the Fairey Rotodyne.

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achievement!

On August 28, 1957, at U.S. Naval Air Test Center, Patuxent River, Maryland, in the presence of Mr. Gates, Secretary of United States Navy, Admiral Thurstan Clark, U.S.N., Commander Naval Test Center, and many U.S. Navy Officials, Flying Officer S. Hughes, R.A.F., ejected at runway level from a Grumman Cougar taking off. This ejection, the first from ground level in America, was done to demonstrate the Martin-Baker Patent Fully Automatic Ejection Seat at present being supplied for U.S. Navy aircraft. The upper photograph shows the main parachute streaming. On the right, Hughes, immediately after the ejection, is being congratulated by the designer of the seat, Mr. James Martin, C.B.E. Design features of this seat are patented in U.S.A. and Great Britain.

Martin-Baker

AIRCRAFT COMPANY LIMITED, ENGLAND & CANADA

THE CANBERRA STORY . . .

Government Aircraft Factories at Fishermen's Bend, Melbourne. The Australian version, the B.20, was modelled on the B.2 and used Commonwealth-built Rolls-Royce Avon engines. By 1957 fifty B.20s had been built.

At the end of 1952 the first contract for the export of British-built Canberras was signed—an order for six B.2s for Venezuela. This welcome sale on January 27, 1953, was made at a comparatively early stage in the life of the aircraft, and it augured well for future overseas sales which have now gone on steadily for six years. This, incidentally, was a sale which reflected fairly directly on the value of the S.B.A.C. display at Farnborough, for it was at the 1952 show that the Venezuelans first saw the Canberra's remarkable qualities and so began negotiations to buy it. Since then a second Venezuelan order has been placed, and delivered, this time for a larger number of B.8s and T.4 dual-control trainers. It was while delivering the final one of the latter versions last month that Mr. John Hackett and Mr. Peter Moneypenny, with Lt. Antonio Leyba of the Venezuelan Air Force, established the official point-to-point record mentioned earlier in this article, from Washington, D.C., to Caracas.

Overseas interest continued, no doubt encouraged by the order to extend production in Britain and by the decisions of the Australians and Americans to make the Canberra under licence. The next country to order from Britain was France, which took delivery of six B.6s during 1954 and 1955 for special flight testing duties at the *Centre d'Essais en Vol*, Bretigny. The next Latin-American order was for six B.6s from Ecuador in May 1954, and then came Peru with an order for eight B.8s in November 1955. The largest order of all came from India in January 1957 for a substantial number of B.8s, PR.7s and T.4s. The number of Indian aircraft involved has not been given by English Electric, but it is reported in New Delhi to total 68, worth more than £20,000,000. In March 1957 the second Venezuelan order was placed and the latest addition to the Canberra customer is the New Zealand Government which last month placed an order, via the Ministry of Supply, for nine B.8s and two T.4s.

That is the export total so far, but the order book is not yet closed. The vast majority of sales in Britain have, of course, been to the Royal Air Force. In all more than 500 Canberras have been built by English Electric at Preston and Accrington (component manufacture) and Samlesbury aerodrome (final assembly); Short Brothers have now produced well over 100 and have a large contract for PR.9s in hand, and A. V. Roe and Handley Page each made 75 aircraft. Over 750 Canberras represent a substantial outlay, but for value for money they are unrivalled.

First flight dates: A.1 (B.1 prototype VN 799), May 13, 1949; B.2 VX 165, April 23, 1950; PR.3 VX 181, March 19, 1950; T.4 WM 467, June 6, 1952; B.5 VX 185, converted B.1; B.6 WJ 754, January 26, 1954; PR.7 WH 774, October 28, 1953; B(I).8 VX 185 (ex-B.5), July 23, 1954; PR.9 WH 793 (converted PR.7), July 8, 1955.

INTERNATIONAL CLASS RECORDS

The Canberra now holds 20 international class records, which is more than any other jet aircraft. Included is the altitude record for aeroplanes of 70,310ft, which was the third successive altitude record set by the Canberra.

Date	Route	Distance (st. mi.)	Time (h. m. s.)	Speed (m.p.h.)
31. 8.51	Aldergrove—Gander ...	2,072	4 18 24.4	481.12
18. 2.52	London—Tripoli	1,459.83	2 41 49.5	538.12
26. 8.52	Ald'gve—Gander—Ald'gve ...	4,144	10 3 29.3	411.99
26. 8.52	Gander—Aldergrove... ...	2,072	3 25 18.1	605.52
28. 9.52	London—Nairobi	4,239	9 55 16.7	427.3
27. 1.53	London—Karachi	3,921	8 52 28.2	441.8
27. 1.53	London—Darwin	8,608	22 0 21.8	391.2
8.10.53	London—Basra	2,832	5 11 5.6	544.3
8/9.10.53	London—Colombo	5,416	10 25 21.5	519.5
8/9.10.53	London—Christchurch, N.Z.	11,796	23 50 42	494.48
17.12.53	London—Capetown	6,009.72	12 21 3.8	487
19.12.53	Capetown—London	6,009.72	13 16 25.2	452.8
27/28. 6.55	Ottawa—London	3,330.416	6 42 12	496.825
23. 8.55	London—New York	3,475.96	7 29 56.7	461.12
23. 8.55	New York—London	3,475.96	6 16 59.5	550.35
23. 8.55	London—New York—London	6,915.92	14 21 45.5	481.52
16. 2.56	Farnborough—Cairo... ...	2,182.6	3 57 18.9	551.8
25. 5.57	Tokyo—West Malling ...	5,942.5	17 42 2.4	335.7
28. 8.57	Altitude record 70,310ft*			
22. 2.58	Washington—Caracas ...	2,057.99	4 11 32	490

*** This Canberra was a B.2 fitted with a Napier Double Scorpion rocket engine in the bomb bay. The aircraft has been used for the flight development of the Double Scorpion which is to be fitted to the English Electric P.1B supersonic fighter.**

The Canberra in Detail

ENGINEERING FEATURES OF THE B(I).8 AND OTHER VARIANTS

As "The Canberra Story" (pages 332-335) has made clear, English Electric's versatile twin-jet stems from design thinking originated immediately after World War 2. The basic design, in fact, was completed more than ten years ago and the first prototype flew in the spring of 1949. The first mark to go into service was the B.2; this was the first R.A.F. jet bomber and also the first British aeroplane to enter service with axial gas-turbine engines (Rolls-Royce Avon RA.3s). This journal published a description and cutaway drawing of the original Canberra design on December 15, 1949.

It is now possible for *Flight* to present a more detailed examination of the most important current mark, the Canberra B(I).8, and to indicate in what respect the major variants at present in production differ. Throughout, it is clear that, like so many aeroplanes in the past, the Canberra is a design which, although by no means young from the structural and aerodynamic viewpoints, has remained highly competitive—and particularly attractive to overseas air forces through its combined merits of low cost, proven efficiency and reliability, ease of conversion and operation and progressive improvement to fit it for widely differing rôles.

As a basic aeroplane it is singularly clean aerodynamically, and the targets aimed at by Mr. Petter when he roughed out the basic design (page 333) were sufficiently modest for it to be capable of manufacture along traditional lines. It has, for example, been possible to employ quite conventional constant-thickness sheet throughout the skinning, and heavy forgings and machined members are conspicuous by their absence, except in such obvious places as the undercarriage attachments and wing-root joints. It follows that the airframe weight is substantially lower than that of similarly sized aircraft of later and faster design, and this fact, allied with the generous wing area of almost 1,000 sq ft, has endowed the aircraft with quite remarkable flying qualities. In fact, bearing in mind the aggregate engine thrust of some 15,000 lb, the manœuvrability and altitude performance of the Canberra are nothing short of remarkable. The latter aspect of performance has been still further improved in the largely redesigned Mk 9 aircraft, as described later.

Except for the Mk 9, all current Canberras have essentially the same airframe. Principle features of the structure are evident from the drawing on pages 336 and 337. It is apparent, for example, that the fuselage is of substantially circular section throughout its length and is assembled from standard frames and longitudinals. Transport joints are provided to divide the structure into three roughly equal portions.

The front fuselage incorporates the complete pressure cockpit, which is terminated at the rear by a flat pressure bulkhead mounted at an oblique angle and bearing the rails for the pilot's ejection seat. The main entrance door is near the nose on the starboard side. It opens outwards and upwards as a single unit, being hinged along its upper edge; in order to provide a dead-air region, and so permit the navigator to abandon the aircraft in emergency, a powered windbreak door is mounted immediately ahead of the main door. In all British-built Canberras the pilot is seated on the port side of the aircraft. Earlier marks have a large symmetrical cut-out above this region, sealed by a clear canopy of blown Perspex, but current versions employ a fighter-type canopy offset to port in line with the pilot's seat. This canopy does not open, but it can be jettisoned by ten explosive bolts and in dire emergency the pilot can fire his Mk 1C ejection seat through the canopy itself.

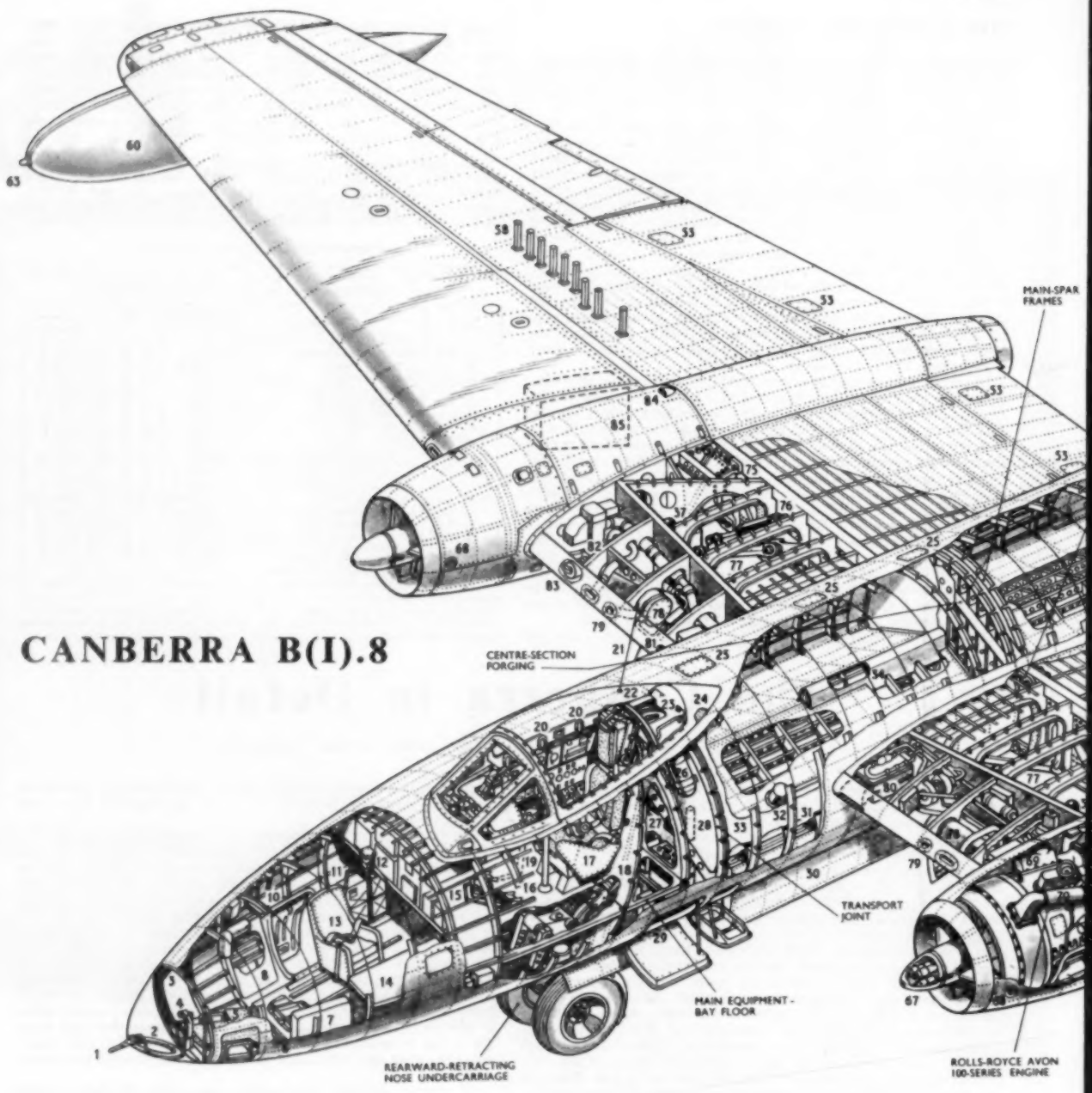
Of almost uniform cross-section, the centre fuselage extends from frames 12 to 31. Two heavy frames at station 21 are aligned with the main wing spar, and are separated by the spar centre-section forging which has attachment forks projecting on each side of the aircraft. Throughout the length of the centre fuselage, provision is made for a bomb bay on the underside and fuel cells above, the two being separated by a strong floor structure of double-skinned construction. Each bomb door is supported on forged brackets at its ends and by rollers operating in the channelled ends of the transverse fuselage frames at seven stations along the bomb bay. The Mk 8 aircraft can be fitted with a gun pack, described later, by removing the bomb doors and installing flare-bay doors ahead of the pack and making other small modifications.

The rear fuselage is of quite conventional construction. It incorporates the stubs of the fin and tailplanes, and an extension at its rear end terminates in a dielectric cap associated with internal electronic equipment.

Aerodynamically related to that of the Meteor, the wing is completely unswept, and outboard of the powerplants tapers sharply from the considerable root chord of 19ft. Port and starboard main-

(Continued on p. 338, after double-page drawing of Canberra B(I).8)

CANBERRA B(I).8



1 Pressure head
2 Optically flat window
3 Bombing control panel
4 Bombsight
5 Prone bombing position
6 Under-floor armour
7 Bombing computer
8 Wind-break door
9 Crew-entry door
10 Crash axe
11 Door jettison handle
12 Signal pistol
13 Navigator's seat
14 Navigator's table
15 Rudder pedals
16 Control column
17 Martin-Baker Mk 1C seat
18 Pressure bulkhead
19 Navigator's take-off seat
20 Canopy-jettison bolts
21 V.H.F. whip aerial
22 Demister unit
23 Canopy-jettison ram
24 Inflatable canopy seal
25 Access to fuel bay and vent galleries
26 Hydraulic reservoir
27 Batteries
28 Front bomb-door jack
29 Port equipment bay
30 Bomb doors
31 Bomb-door rollers
32 Fuel booster pump
33 Fuel tank skin
34 Fuselage keel structure
35 Loop-aerial hatch
36 Camera
37 Extinguisher bottle
38 Bomb-bay bulkhead
39 Camera hatch
40 Elevator and rudder control-rods
41 Aerial
42 Fuel vent-pipe outlet
43 Tail bumper
44 Rear bulkhead
45 Rudder control linkage
46 Bracing strut
47 Tailplane actuator
48 Elevator mass-balance
49 Wooden fin structure
50 Navigation light
51 Rudder mass-balance
52 Spoiler
53 Flap mechanism access
54 Flap actuation and hinges
55 Drum-switch
56 Flap-operating jack
57 Jet-pipe support rail
58 Air-brake drag channels
59 External stores pylon
60 Jettisonable fuel tank
61 Drain
62 Filler
63 Navig
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66 Nose
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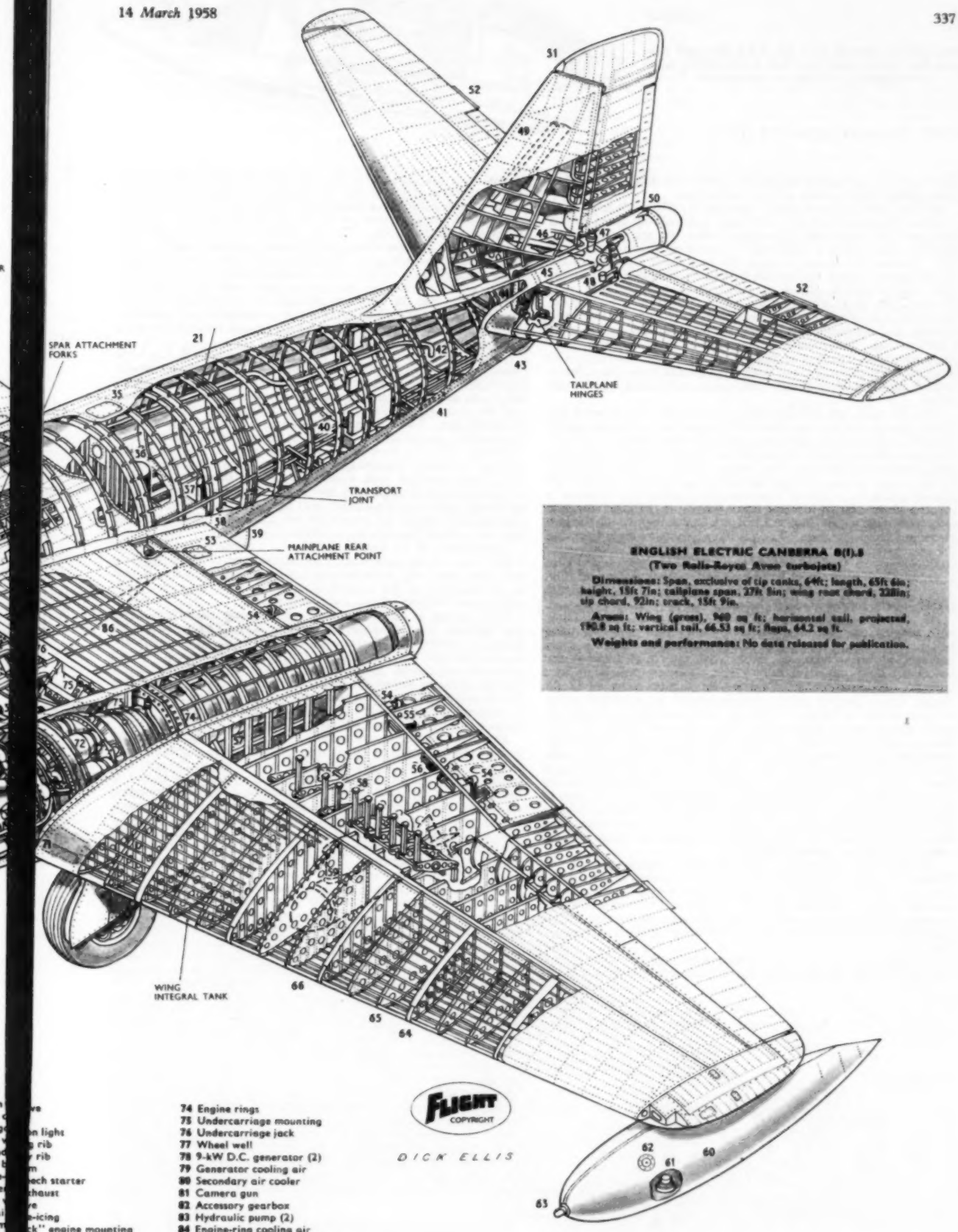
72 Flame
73 Firew



ENGLISH ELECTRIC CANBERRA B(I).8
(Two Rolls-Royce Avon turbojets)

Dimensions: Span, exclusive of tip tanks, 64ft; length, 65ft 6in; height, 15ft 7in; tailplane span, 27ft 8in; wing root chord, 228in; tip chord, 92in; track, 15ft 9in.

Areas: Wing (gross), 960 sq ft; horizontal tail, projected, 190.8 sq ft; vertical tail, 66.53 sq ft; flaps, 64.2 sq ft.

Weights and performance: No data released for publication.

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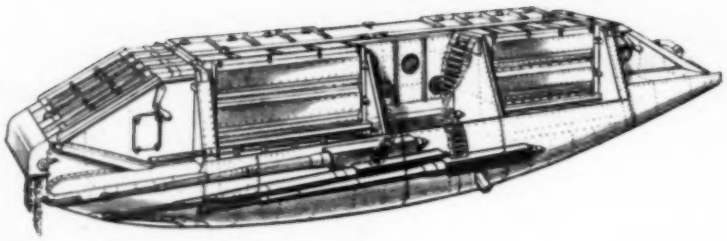
74 Engine rings
75 Undercarriage mounting
76 Undercarriage jack
77 Wheel well
78 9-kW D.C. generator (2)
79 Generator cooling air
80 Secondary air cooler
81 Camera gun
82 Accessory gearbox
83 Hydraulic pump (2)
84 Engine-ring cooling air
85 Fuel collector box
86 Gun-pack (see sketch overleaf)



Developed by Boulton Paul, the B(I).8 gun-pack contains four 20 mm guns, and four tanks holding many hundreds of rounds of ammunition.

THE CANBERRA STORY . . .

planes are built separately and are attached to anchorages projecting from strong bridge-pieces within the fuselage.

Bending loads are principally absorbed by the single main spar at about 40 per cent chord. This spar is a built-up beam with a plate web and machined light-alloy booms, the section of which changes from a plain T at the tip to a complex T-like form at the root. Around the engine jet-pipe the spar loads are transmitted by the booms (which are unbroken) and by massive forged light-alloy ring-members, ahead of which is a heat-resistant steel fire-wall. The main wing box is completed by what is termed the rear wall, consisting of a spanwise web ahead of the flaps and ailerons and connected across the jet-pipe cut-out by a forged I-section ring. The remaining structure of sheet ribs and bulb-angle spanwise stringers is clearly shown in the drawing. The complete assembly is skinned with constant-thickness sheet, flush-riveted throughout and with butt-joints reinforced by doubler strips.

Like the wing, the tailplane has a single spar well forward and a false spar at the trailing edge of the main box (although, unlike the wing, this rearmost member can run straight from root to tip). Port and starboard tailplanes are joined by transverse bridge pieces lying within the fuselage. The bridge piece, or "centre section," for the main spar is a forged light-alloy member, on the forward face of which are a pair of trunnions upon which the tailplane is pivoted to the rear of fuselage frame 42. Near the false rear spar is an anchorage for an English Electric actuator with which the tail-plane incidence is varied. The fin likewise has a single spar, but the structure is otherwise most unconventional; the leading-edge portion (back to some 60 per cent chord) comprises wooden ribs, a leading-edge member of laminated spruce and a plywood skin. The rearmost edges of the skin are Reduxed to the T-section booms on the forward face of the spar.

All the control surfaces are of quite conventional construction, with single spars, pressed-sheet ribs and light-gauge skinning behind a D-section nose. The ailerons have inset hinges and are balanced by an aerodynamic beak (with critical clearances) and adjustable strips of heavy alloy. The elevators have large horn balances and mass balances carried on tubular arms while the rudder has a similar system supplemented by a second mass-balance weight in the tip of the horn. Both ailerons are fitted with conventional spring tabs, and similar surfaces are carried by both elevators and the rudder. All control circuits are operated through push/pull tubes from pedals and a "spectacles" stick in the cock-pit. For trimming purposes, the tailplane-actuator switch is located close to the pilot's thumb. Lateral trim is accomplished by a biassing circuit, controlled by an electric actuator, at the base of the control column. For asymmetric flying the rudder tab can be offset by an *ad hoc* actuator which positions the outer spring-tab torque tube. In addition, the starboard elevator tab can be adjusted on the ground for trimming purposes.

For emergency purposes, a control-column snatch unit is fitted. Should the pilot wish to leave the aircraft by means of his ejection seat, he can, by pulling his screened snatch-unit handle on his control console, sever the elevator control and release a powerful spring which pulls the control column forward against the instrument panel. This provides the pilot with an unobstructed escape path.

Split flaps are fitted in four portions beneath the wings. Each surface is a very simple triangular-section structure with a single pressed spar and an upper skin liberally provided with flanged lightening holes. Each of the four sections is hung on two hinges and is operated through a bell-crank linkage by a single hydraulic jack behind the rear wall of the wing which operates through spanwise push-pull rods. The air brakes are less conventional, and comprise 21 drag-channels disposed vertically within each wing behind the main spar. When the brakes are closed, the ends of the channels lie flush with the surface of the wing. As the large cut-away drawing clarifies, they can be made to project a consider-able distance into the airstream through an assemblage of rocker arms at a torque tube which is pivoted by a hydraulic jack anchored to the rear wall. Twelve of the channels project beneath the wing and nine above.

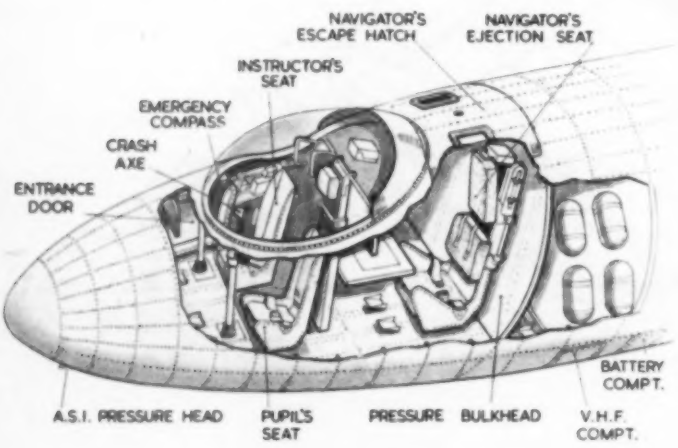
Design and manufacture of the main undercarriage has been handled by English Electric. Each unit comprises a single forged light-alloy leg containing an oleo-pneumatic strut inflated to about 400 lb/sq in. Tyres, wheels and plate brakes are all by Dunlop, and the unit retracts inwards into the wing under the pull of a hydraulic jack. The nose gear is mounted well aft, actually being attached to a pair of forged brackets on the rear face of the pressure bulkhead. The leg itself is a levered suspension, Liquid Spring product of Dowty Equipment, and it carries twin Dunlop wheel units each provided with a mudguard. The complete assembly is hydraulically retracted to the rear and the wheels are fully castering, with a spring-loaded centring mechanism which damps shimmy and centres the wheels for retraction. A rubber-shod tail bumper is fitted beneath the rear fuselage.

Powerplants of all British production Canberras are a pair of Rolls-Royce Avon turbojets. The precise type of Avon fitted to any given mark of Canberra may not be published, but it is safe to assume that all the aircraft at present in service have "first-generation" engines of the Avon 100 series.

Each engine is carried on four self-aligning mountings. The rear mounts are spherically-radiused collars fitted to trunnions bolted to either side of the engine nozzle box. The collars are located between bearing-blocks bolted directly to the inboard and outboard engine ribs. Corresponding anchorages are bolted to the extreme forward end of the engine ribs; each carries a cup bracket within which is a ball socket on the end of a tie-rod from which is suspended the adjacent front mounting of the engine on the lower part of the compressor casing.

From the engine exhaust-cone a transition piece, secured by a clamping ring, leads to the jet-pipe proper which passes through the wing spar banjo and through the forged ring in the rear wall of the wing box. At its forward end each jet-pipe is bolted to the transition piece and is also supported by a pair of lugs resting on channel-section runners which form part of the wing structure. At the rear, the pipe is provided with a housing bracket on either side which locates an eccentric spigot in the rear-wall ring; the latter allows the pipe to expand axially and provides for vertical alignment on installation. Access to the complete powerplant is available by the removal of four panels. Much the largest is the front cowl, which encloses the complete engine and is removed in a forwards direction. Beneath the wing leading edge is a semi-circular service panel, and the run of the jet-pipe is covered by upper and lower rear cowls. All these portions are attached to each other or to the wing by Dzus fasteners and toggle latches.

A full description of the 100-series Rolls-Royce Avon was published in our issue of December 16, 1955; the more powerful 200-series engine was described in our issue of October 11, 1957. Most of the 100-series Avons of Canberras so far built can be seen to be essentially of the RA.7 or RA.21 rating (7,500/8,000 lb) although the first production aircraft clearly had the 6,500 lb RA.3, which is also fitted to the Canberra T.4 trainer. These early engines generally have single-breech turbo-starters mounted within the streamlined bullet in the centre of the intake. The later engines, such as those fitted to the B(I).8, have a triple-breech starter which gives rise to a longer bullet which projects well ahead of the intake lip. Exhaust from the starter is discharged to atmosphere through a radial duct across the intake terminating in a flush vent in the outer skin of the front cowl. The lubrication system, using OX-38 (OX-11 on earlier aircraft) oil, is self-contained within each engine, oil cooling being effected by a heat exchanger through which is passed oil and high-pressure fuel. Each Avon wheelcase drives an extension shaft coupled to a Rotol



Retaining the original front fuselage, the T.4 trainer seats instructor and pupil side-by-side; the navigator has an ejection seat behind. Many T.4s are converted B.2 bombers.

accessory gearbox within the wing on the inboard side of the jet-pipe.

Security regulations forbid publication of the precise location of the fuel tankage and of its capacity. It can, however, be said that the majority of the Canberra's fuel is located in three tanks in the upper part of the fuselage above the bomb bay. The forward and centre tanks are flexible self-sealing cells with internal bracing while the rearmost tank is a crash-proof collapsible bag. In certain types of Canberra (obviously including the PR.7 and B(I).8) additional internal fuel is carried within the wings, giving a substantial increase in range. All marks of Canberra are cleared to carry jettisonable streamlined tanks beneath the wing tips, each with a capacity of 244 Imp. gal (293 U.S. gal). S.B.A.C. flush fillers are provided in the top decking of the fuselage for gravity filling, and late-model Canberras, including the Mk 8, have additional fillers in the wings. Fire protection is provided by three methyl-bromide extinguisher bottles, two of which serve the powerplants and one the fuselage tankage and bomb bay.

Pressurization of the crew compartment is effected by air bled from the Avon compressors. The hot bleed air is controlled by Teddington gate-valves and taken into a common duct between the powerplants. Hot air is fed directly to cameras, the gun-pack and other operational equipment, while the major proportion is passed through primary and secondary coolers in the wing leading edges and through a Godfrey cold-air unit. Finally, supplies of hot and cold air are fed to a two-way mixing valve giving air of the required temperature and quality for the cabin. The air is passed through a water extractor and individual supplies are provided for each crew member and for canopy and bombing-panel demisting.

Electrical power is generated and distributed at a nominal voltage of 24/27.5 using a single-pole D.C. system. The system is energized by a pair of 9kW Type 512 generators operating in parallel and driven off the accessory gearbox inboard of the powerplants. Rotary inverters provide supplies of 400 c/s three-phase and 1,600 c/s single-phase current for instruments and electronics.

Each of the two accessory gearboxes drives a Lockheed Mk 7 hydraulic pump which energizes the hydraulic system to 2,700/3,000 lb/sq in. The system serves the undercarriage retraction, flaps, air brakes, bomb doors and wheel brakes. OM-15 fluid (mineral-based) is employed, the reservoir being located on frame 12 at the extreme rear of the front fuselage. A small self-contained system can be energized by an air bottle to operate the windbreak door already mentioned.

In the Mk 8 Canberra, oxygen for the crew is carried in a gaseous form in two cylinders each of 2,550 litres capacity and two of 750 litres capacity. All four bottles are mounted in the equipment compartment behind the pressure bulkhead; the cylinders are arranged in isolated pairs, the high-pressure circuit being duplicated.

Little can be said of the many items of weapon-system equipment carried by advanced models of Canberra, and these do in any case differ according to the sub-type of aircraft concerned. Most Canberras, however, are fitted with T.R. 1985/1986 V.H.F. communications radio, the sets themselves being mounted immediately behind the pressure bulkhead on the port side of the fuselage, the associated whip aerials being mounted above the fuselage on the centreline. A conventional I.L.S. system is fitted, the equipment being mounted beneath the pilot's floor and the aerials comprising a marker aerial in the starboard mainwheel bay, a glide-path aerial in the outer starboard wing leading-edge and a localizer aerial in the outer port leading-edge. When a radio altimeter is fitted two dipole aerials are provided for the system on the underside of the rear fuselage. Should Gee be fitted, the system is served by an L-shaped wire-mesh aerial mounted within the wooden structure of the fin.

No precise details may be given of the dimensions of the bomb bay, nor may the full range of possible internal loads be published. It is, however, known that Canberras employed in bomber rôles by the Royal Air Force are capable of carrying kiloton-yield nuclear stores. A very wide range of conventional stores can be accommodated, including six 1,000 lb bombs or mines of various marks on a pair of Mk 2 triple carriers (which were specially designed for the Canberra by A. V. Roe and Co.). Three triple carriers can be used to accommodate six 800-lb clusters of incendiaries or eighteen 100 lb practice bombs. Aft of the main spar on each outer wing a single pylon is provided for a stores load of 1,000 lb. Visual bombing can be conducted from a prone position in the nose, and more sophisticated means of delivery —including automatic LABS (*Flight*, December 27 last)—are also possible.

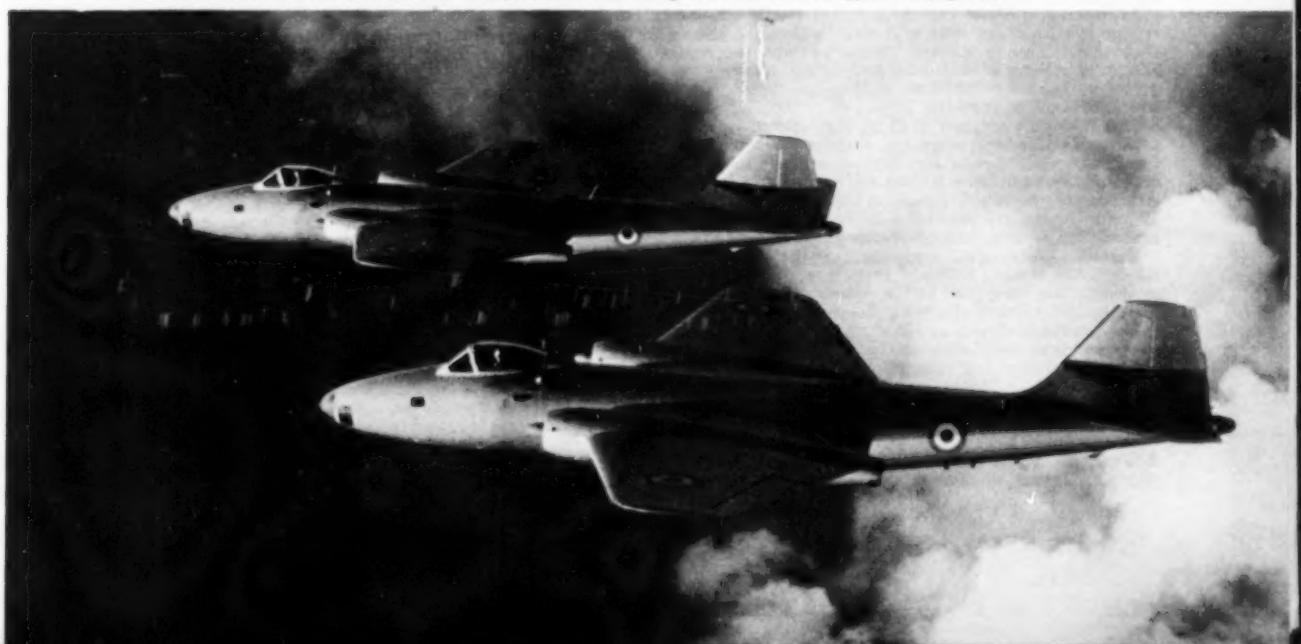
When operating in the interdictor rôle, the secondary bomb beams are removed to enable a large gun pack to be accommodated in the rear part of the weapons bay. As an accompanying drawing shows, this pack houses four 20 mm Hispano guns. Provision is made for the carriage of a very great quantity of ammunition (reported to be sufficient for 55 seconds' continuous firing), and the pack is provided with full heating and gas-purging systems. Associated with the pack is a G45B cine-camera which is mounted in the inner starboard leading-edge. When the pack is installed, the forward part of the bomb bay can be used to house sixteen 4.5in flares or a single Avro triple carrier upon which three 1,000-lb stores can be mounted.

This concludes the description of what is possibly the most important mark of Canberra at present in production. Owing to its remarkable versatility the Mk 8 has superseded some earlier single-purpose Canberras in R.A.F. service, and it is also employed by the Air Forces of India, Venezuela and Peru (soon, New Zealand). Numerous Mk 6 bombers in R.A.F. service have been converted to the B(I).6 standard by making provision for them to carry underwing stores and a bomb-bay gun pack.

Some hundreds of aircraft originally built for the R.A.F. as B.2s are still flying, and many of these have been brought up to T.4 standard and are now used for type-conversion and miscellaneous duties by Bomber Command and other R.A.F. and M.o.S. units. This conversion is referred to in "The Canberra Story" on page 334, and a T.4 crew compartment is shown in an accompanying diagram.

As at present visualized, the final mark of Canberra is the PR.9. Basic design and engineering work for this model was conducted by English Electric and a development aircraft, WH 793, has been flying for three years. Detail design and production of the PR.9 has been assigned to Short Brothers and Harland, Ltd., at Belfast, and photographs of PR.9s during manufacture were published in our issue of January 17. The first production PR.9 will fly later this year. The aircraft differs substantially from all earlier Canberras and has a much improved performance at altitude; but further details of the Mk 9 must await the emergence of this aircraft from the Queen's Island factory.

Two Canberra Mk 8s of the Indian Air Force; a three-view drawing of a Peruvian Mk 8 appears on page 331.



". . . revelation of the massive supersonic CF-105 Arrow was a reminder that Canada will still take the lead to defend her own skies . . ."

Canada's Air Defence Policy

The R.C.A.F. in a Transition Stage

By JOHN D. HARBRON

AT no time during the 13 years since the end of World War Two have Canada's Royal Canadian Air Force and Department of National Defence chiefs had so many conflicting problems related to air defence and the build-up of military aviation as they have now. Moreover, the likelihood of resolving them in the near future seems remote indeed.

Not only did the Government change unexpectedly last year, bringing with it a new Defence Minister, but there is constant concern as to whether the country's small but tactically vital air force should submit partially or entirely to the American concept that North American air defence now relies on the volume output of guided missiles and the deterrent of the Strategic Air Command. The recent creation of NORAD (North American Air Defense Headquarters), in Colorado, with a Canadian as deputy commander, shows a positive swing toward U.S. thinking. But Canadian criticism of U.S. continental air-defence methods—aroused in the House of Commons and by the wary Press—indicates that, Soviet missile threat or no, Canadian nationalism still must have its say. A fear that some over-eager American general will "slip the leash" before a real emergency has been determined indicates that some Canadian thinking, like that of Western Europe, is perhaps over-concerned with American inability to keep completely calm in the face of the threat of a surprise attack coming true some day.

Add to this the possibility that Canada's reserve forces units, geared to the pre-nuclear age training programme of week-night drills and annual fortnightly summer training camps, might now be merged to form a trained civilian nucleus for a disciplined civil defence organization, has caused much resentment among the country's proud reserve air squadrons.

A fourth and perhaps equally difficult problem to solve at the present time, is how the new Conservative Government, heavily committed to pre-election promises of reductions in income tax and increases in social security benefits for which it must now find the funds, can reconcile these with finding the hundreds of millions of dollars needed to keep the orders coming for Canada's small, highly active but Government-reliant aviation industry. Since the Conservatives did not expect to defeat the 22-year-old Liberal regime last June, but only to cripple it, they also did not expect they would have to concern themselves with the confliction of allocating millions of dollars for larger social security measures by paring millions of dollars from defence estimates. Now the problem is squarely in their lap.

If it is any consolation to them, the sight of two Soviet earth satellites in Canadian skies last autumn did much to move the Canadian public's basic anti-military attitude toward a realistic consideration of military aircraft and guided missile requirements. Accordingly, the general public in Canada, like the long-suffering R.C.A.F. heads, are beginning to wonder what the solutions to not one but several defence dilemmas are going to be.

Certainly the public revelation of the massive supersonic CF-105 Arrow was a reminder that Canada still will take the lead to defend her own skies in the estimated ten-minute interlude between identification of a Soviet bomber attack by DEWline radar stations in the far North and the alerting of S.A.C. defensive units to the south in the United States.

In November of last year, Canada's new Minister of National Defence, the Hon. Mr. George Pearkes, a retired major-general of the Canadian Army and a World War One hero, announced that the Government would continue development of the Arrow until December 1958 in conjunction with Avro Aircraft, but that this was not a production contract. In December, however, the Minister announced that the Government would take 40 of the supersonic fighters, to cost about $300 millions, thus assuring more steady employment for Avro's 15,000 employees and approximately 650 sub-contractors across Canada.

In this way Mr. Pearkes not only preserves an industry for a further limited period, but also gives the Government an "out" if the U.S.S.R. should entirely halt the manufacture of manned, intercontinental bombers in place of ballistic missiles; or if defensively oriented missiles, superior to the Arrow in tactical usage, are developed in the U.S.A. or the United Kingdom.

Nevertheless, criticism in some Canadian circles about the appearance right now of this ultra-expensive manned aircraft, when Britain, if not the United States, was nearing the end of the manned aircraft era, was hot and furious. "A dead duck," said one critic. "Let's immediately scrap this $200 million dollar plan," said another. The announcement that Avro would cease production of the Mk 6 CF-100 (a CF-100 carrying the Sparrow air-to-air missile instead of rockets), added to concern in the U.S.A. that Canada's air defence policy, in spite of NORAD, was going against the streams of current technological advance.

Fortunately, the development of the Arrow, the arrival of the Canadair CL-28 Argus for the R.C.A.F.'s future coastal patrol work and the steady production of the Orenda-Sabre for both the R.C.A.F. and West Germany's new Luftwaffe do not point so conclusively to a retrogressive Canadian air defence policy.

The new administration, traditionally the party of Canadian nationalism and the protector of infant Canadian industry, could scarcely leave the nation's aircraft manufacturers far out on a limb. Take the big, new Arrow. There is wide room for positive argument that the U.S.S.R. is counting on large jet bombers to deliver the initial punch from the air and is even building newer and faster bomber types. The Arrow could serve as a defensive fighter for perhaps the next three to five years, to be ultimately augmented and finally replaced by the arrival of missiles from either Canadian or American plants. Also, it would fit ideally into Canada's squadrons under S.A.C. which operate from headquarters at St. Hubert, Quebec, near Montreal.

As for the aviation companies themselves, they are interested in more than just developing expensive new types whose future is in doubt. Avro Aircraft are now interested in exporting the CF-100 to possible foreign buyers; but they are prohibited from selling it to many nations because of the security classification placed by the Americans on the U.S.-made fire-control mechanism. For example, Avro could not seek orders for CF-100s from Poland, or a country open to permanent or temporary internal Communist infiltration such as Indonesia. However, a major sale to Belgium's Royal Air Force, a safe NATO country, was made last year.

Orenda Engines, Ltd. (the highly efficient sister company of Avro Aircraft), which sold 225 Orenda engines and spares for West Germany's Canadair-built Sabres, has another problem. Will sales of the Orenda, a relatively powerful and expensive engine, always be military ones? There have been other military takers, such as the Union of South Africa, which ordered about 50 Orendas during 1957. Even more disturbing is the fact that the days are already numbered when the Sabres, now semi-obsolescent aircraft, will be saleable anywhere and presumably the Orenda engines which go into them.

Basically then, the traditional concern of aviation manufacturers in Canada, as elsewhere in the free world, is how to get the non-government orders which bridge the "feast and famine" production picture of the industry, a result of the ebb and flow of government orders for aircraft and funds for new development.

Paradoxically, domestic critics of A. V. Roe Canada (parent

company of Avro Aircraft and Orenda Engines) and its big plans, are equally vociferous in their objections to the stockpiling of American tactical and strategic long-range missiles on Canadian soil. "We don't want to become the West Germany of the North American continent," said one of them recently. In spite of firm denials, U.S. tactical missiles could be in supply in Canada already. In any case, a group of Canadian firms can make the Sparrow 2 under licence from Douglas Aircraft whenever the Government gives them the green light to do so. Unfortunately, the nationalists have one strong talking point in their favour. This is the dismal story of Velvet Glove, an air-to-air missile stated to be Canada's very own contribution to military rocketry. First fired in 1950, it was to be available for the R.C.A.F. in volume in 1955. But two years ago, it was suddenly dropped in favour of Sparrow. Militarily, this was probably a wise decision; but where defence thinking is concerned Canadian public opinion is a wary, frustrating and often unreasonable force to deal with.

As for the recent NORAD arrangements, it is about as sensible a working structure as both the U.S.A. and Canada can rationally expect at this time. While Canada is geographically one of the world's largest nations and strategically one of the most vital, from the viewpoint of the physical size of her air power, she is scarcely a middle power. Yet NORAD's deputy commander, 53-year-old Air Marshal C. Roy Slemon—who has been an Air Force officer since 1924 and who was one of Canada's "bush-whacking" pilots of the 1920s—would "push the button" for both the U.S.A. and Canada if the American Lt-Gen. Partridge, NORAD's commander, were unable to do so. Originally created with the agreement and co-operation of the former Liberal administration, the structure of NORAD was made public last summer by Prime Minister John Diefenbaker's new Conservative regime.

Just as vital is the future of Canada's proud reserve air units. Almost as old as the permanent R.C.A.F., and depositories of as much tradition as permanent force squadrons, they never forget that Canada's superb contribution of leadership in the air war against Nazi Germany was made mainly from the wartime ranks of the reserve squadrons. Take, for example, Toronto's No. 400 (City of Toronto) Auxiliary Squadron, founded in 1932. It has given three air commodores and five group captains to the R.C.A.F. Air Chief Marshal Wilfrid A. Curtis, Chief of the Air Staff from 1947 to 1953 and main Air Force architect of the CF-100, came from No. 400. It was the first auxiliary squadron to go overseas, supported the ill-starred Canadian commando raid on Dieppe in August 1942, and did high-altitude photo reconaissance for the pinpoint bombing of Germany's V-2 bases during 1944 and early 1945.

". . . some auxiliary R.C.A.F. squadrons would continue to take over the rôle of A.C. and W. (air control and warning units)." An airwoman of No. 2416 A.C. and W. unit on duty.

There are 11 reserve operational squadrons in the R.C.A.F. today. Six of these fly the Mk 5 Sabre. The rest are operating in the light transport rôle. In the last few years week-end pilots of the Air Force Reserve—businessmen, professional men, students, salesmen—have graduated from Vampires to Sabres given to the squadrons during 1956. But the next step is into CF-100s.

However, reserve pilots do not have the time to master these complex machines in spare-time flying hours. Add to this the nebulous Canadian Government policy to bring about the merger of all reserve units into a master C.D. organization for the nuclear era and the long-term future of the air force's auxiliary squadrons looks bleak. In December, 1957, Defence Minister George Pearkes announced that some auxiliary R.C.A.F. squadrons would continue to take over the rôle of A.C. and W. (air control and warning units). The other reserve squadrons with the Sabres have been downgraded from the permanent force's "immediate alert" aircrew status in case of attack to a 24-hour status. It is understood that members of some squadrons on A.C. and W. duties are already integrated parts of the Pinetree Line operations, indicating that R.C.A.F. planning of this kind has been going on for some time.

Will the six Sabre reserve squadrons at Canada's largest cities (two each at Vancouver, Toronto and Montreal), keep their fighters to aid in their cities' defence? Right now, no one is saying. But the new slower Sabres of the auxiliary squadrons, handed over from Canada's permanent force units in Europe, could not cope with the types which the Russians have developed since the Sabre was the front-line fighter of the Korean War. This probably means the auxiliaries will fly very light aircraft in the transport rôle, such as more Expediters and the superb D.H. Canada Otters. Some

(*Continued on page 343*)

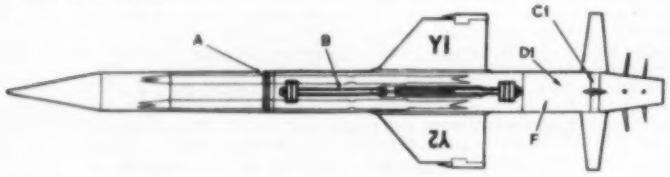
"Will the six Sabre reserve squadrons at Canada's largest cities keep their fighters? . . ." An R.C.A.F. photograph of Canadair-built F-86s of Nos. 438 and 401 (Auxiliary) Squadrons over the Jacques Cartier Bridge, Montreal.

Test Vehicle Development

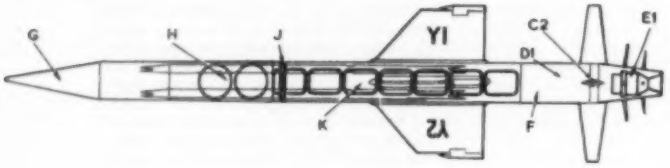
VARIANTS OF THE SHORT G.P.V.

Short general-purpose vehicle under test on the M.o.S. Aberporth range. The eight boost motors are burning.

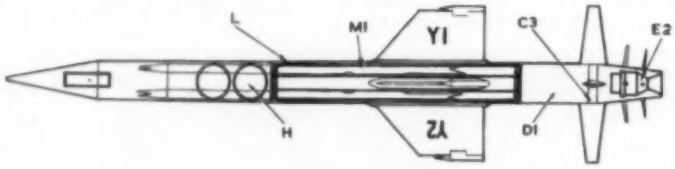
'SHORT ROUND' – COLD



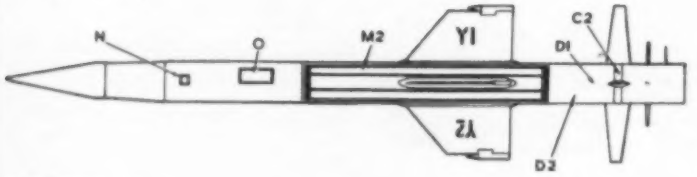
'SHORT ROUND' – HOT



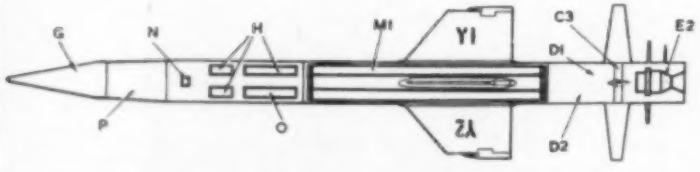
'SHORT ROUND – 'C' CONTROL



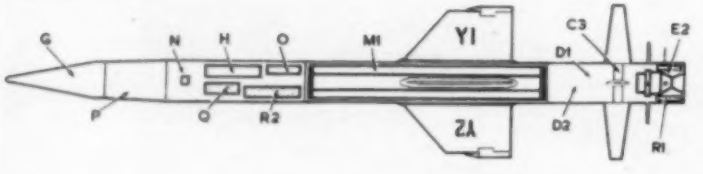
'LONG ROUND' – COLD



'LONG ROUND' – HOT



'RECOVERY ROUND'



THE Short general-purpose vehicle is, as its name implies, a missile of unusual versatility. This is a virtue particularly commendable at the present time. The use of one missile for a variety of purposes, notably for research to provide data for all British firms working on guided weapons, in some ways reflects the broader fundamental principle now being applied to the aviation industry generally. Research with the Short G.P.V. has actually been conducted on this basis for several years.

Until now, no detailed account has been given of the way in which the missile has been progressively developed, through a series of variants, for successive phases of research. These variants have included a number of "cold" rounds, that is, missiles having no sustainer motor but being capable of travelling far enough during and after the boost phase to prove aerodynamic performance.

Shorts' work on the G.P.V. dates from the time when, initially in collaboration with the Royal Aircraft Establishment, the company took over development of the already advanced R.T.V.2. In order to reduce production costs Shorts undertook, as one of the first tasks, a complete redesign of the structure while retaining the existing configuration. Among the uses to which the G.P.V. was to be applied was the testing of various forms of tankage, and for this reason it was essential to use a centre-body that did not form an integral part of the tankage system, as was the case in R.T.V.2. In addition, sufficient space was provided for a blast tube at the rear of the round, thus providing for the installation of a "solid" sustainer motor should this be decided on at a later date.

The first rounds, which employed an actuator similar to that of the R.T.V.2, were used mainly for strength tests, and results achieved with rounds programmed to give maximum accelerations showed that a degree of strengthening was in fact necessary. This was effected by the introduction of steel strips or "corsets," as shown in the first drawing in the accompanying illustrations. They proved effective and were retained in the next two variants. (The rounds illustrated, it should be noted, are the principal versions and are themselves capable of break-down into other variants.)

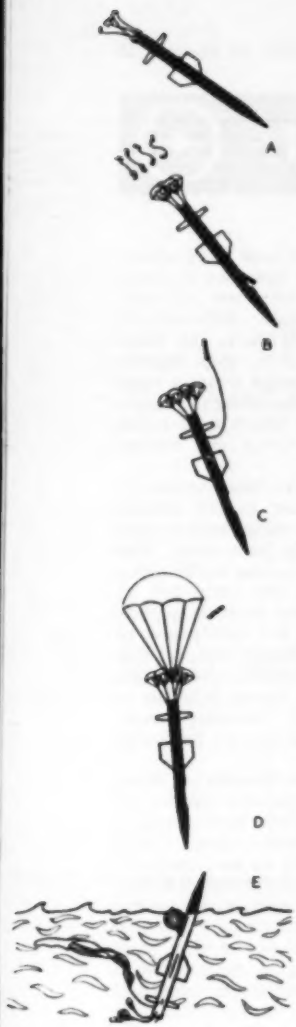
The next step was to introduce a propulsion system in which the method of tankage was changed from that used in R.T.V.2 to incorporate a number of reversible plastic bags. Here the main difficulty was to ensure compatibility with the use of high-test peroxide and to prevent the centre of gravity from changing during expulsion of fuel by high-pressure nitrogen containers.

At about this time it was found that the original actuator did not possess the degree of movement necessary for the desired manœuvrability. A new type was under development, but as an interim measure a version based largely on the early actuator (though capable of greater movement) was introduced. As with previous rounds, pressure for oil expulsion to work the hydraulic control system was supplied by a cordite charge, and it was also during this period that first flight-tests were made on a radome of the kind envisaged for later guidance-trials.

In a third main variant, the interim actuator was replaced by a newly developed hydraulic actuator designed by R.A.E. and manufactured by H. M. Hobson, Ltd. The casting for the actuator

Progressive development of Short G.P.V. through a series of variants.

A, break-up plastic explosive; B, ballast; C1, A-type actuator; C2, B-type actuator; C3, C-type actuator; D1, A-type telemetry; D2, B-type telemetry; E1, A-type motor; E2, B-type motor; F, cordite oil expulsion; G, radome; H, nitrogen containers for fuel expulsion; J, break-up Cordtex; K, bag tanks; L, oil-system nitrogen container; M1, seven-tube tankage; M2, dummy seven-tube tankage; N, missile tracking system; O, alternator; P, Elliott homing head; Q, buoyancy bag; R1, first-stage parachutes; R2, second-stage parachutes.



***Stages in release of first- and second-stage recovery parachutes and flotation bag:*— A, release of four small parachutes from rear of vehicle; B, first-stage parachutes open; C, panel over main parachute container is ejected by explosive jack; D, second-stage parachute opens; E, vehicle supported in water by flotation bag inflated by CO_2 supply initiated by "sea cells."**

frame had originally been designed for use with different actuators, and no change was necessary. Used with this actuator was a different method of oil expulsion—introduced because it was desired to achieve a period of operation longer than that available from the cordite expulsion system. Here it was expedient to make use of high-pressure nitrogen stored in coiled tubes in the centre-body, since the space previously occupied by the cordite was needed for greater oil capacity.

Another future requirement already apparent was provision for recovery and guidance equipment. A major change was accordingly introduced. The front portion of the round was lengthened and, with the object of saving space, experiments were made to investigate the possibility of replacing the existing high-pressure-nitrogen fuel-expulsion system by a slow-burning cordite charge. It was appreciated, however, that there would probably be some difficulty with heat generated by the cordite and that, in particular, the plastic bags would suffer. The bag tanks were therefore replaced by an assembly of seven aluminium tubes and this system was flight-tested in "short" rounds whilst still retaining the nitrogen spheres as a source of power for fuel supply. A different type of motor, designed by the R.A.E. at Westcott, was also successfully flown at about this time.

With the introduction of the "long" round the opportunity was taken integrally to strengthen the structure and so avoid the use of the longitudinal steel straps. A number of "cold" rounds were again fired to flight-test components to be used later on fully guided rounds.

Pending the conclusion of ground tests on the cordite fuel-expulsion system, the use of high-pressure nitrogen was retained, but the spherical containers were replaced by bottles. These were more economical in shape for packaging purposes. It was soon apparent that development of the cordite system would take longer than had been expected, and further research showed that the use of nitrogen, at a pressure greater than that previously employed, would permit packaging of all components necessary for a fully guided and recoverable round. For this reason, the cordite system was not, in the event, embodied in flight rounds.

Meanwhile, a new phase of research had begun with the investigation of homing problems in collaboration with Elliott Brothers (London), Ltd.; and, facilitated by the use of the recovery system, this programme continues.

The release of parachutes in two stages, and of the flotation bag, is ingeniously contrived. Four small parachutes housed at the rear of the round are enclosed by a steel strap which, by means of a time clock, is released at a predetermined stage of the flight. The steel strap straightens and flies off, and the parachutes are released, checking the rate of the missile's descent towards the sea.

In the second stage a charge controlling a jack is exploded, thus ejecting the panel fitted over the main parachute container at the front of the vehicle. The main parachute is thrown out and its steel cable breaks away from a retaining strip along the side of the round, so that when it is fully inflated the missile is suspended from the ultimate attachment-point near the rear fins.

With the missile's entry into the sea the flotation bag, housed in the compartment which contained the large parachute, comes into use. "Sea cells," operating on contact with salt water, close an electric contact, thus releasing CO_2, which inflates the bag. This is, of course, highly coloured and makes a conspicuous marker for the recovery crews.

Aerodynamic work on the G.P.V. has been carried out with the "cold" rounds already mentioned, with scale models, and by wind tunnel testing. This work proved of great help in working out round trajectories during subsequent collaboration with Elliott Brothers on the study of homing problems.

Wind-tunnel tests have covered both low-speed and supersonic work, the latter with the aid of the R.A.E. Low-speed research has yielded data on pressure distribution, both circumferential and longitudinal, on the body of the missile, and has determined the subsonic lateral characteristics of both boosted and unboosted rounds. Supersonic tests have included investigation of control effectiveness and induced effects, together with component aerodynamics, followed by runs with the complete long round.

Employment of telemetry for obtaining flight data for subsequent analysis is of prime importance in a vehicle such as the G.P.V., and use is at present being made of two different types of telesenders, for both of which Shorts are responsible.

CANADA'S AIR DEFENCE POLICY (continued from page 341)

critics feel that at the present time too many obsolete Dakotas, C-119 "Flying Boxcars" and even Lancasters still clutter the R.C.A.F. transport squadrons both in the reserves and in the permanent force's Air Transport Command. But in November last year the submarine patrol of No. 407 Maritime Patrol Squadron at Comox, B.C., put their dozen Lancasters to rest, almost the last of 6,000 of the famous bombers which flew in European, British and Canadian skies. Soon to appear in the military air transport field in Canada is the CL-44, the Canadian version of the Bristol Britannia; and for lighter duties, the twin-engined DHC-4 Caribou transport, suitable for work in the Canadian North, is now under development at de Havilland at Downsview, Ontario.

However, the Suez crisis last November revealed how crude Canada's troop-carrying facilities had become. It took more than a dozen flights to move 1,000 members of Canada's Queen's Own Rifles from their barracks in Calgary, Alberta, to the port of departure at Halifax, N.S., for the United Nations Special Force in the Middle East. One-way flight between Calgary and Halifax is a distance of about 2,500 miles. Elsewhere, army critics, led by a retired army Chief of Staff, can always point at the Canadian Army's inability in the decade or more since the war to establish an effective, available airborne infantry battalion, ready for such an emergency as the Suez crisis suddenly offered.

In the permanent R.C.A.F., the basic concern of building enough modern aircraft and aero engines for Canada's home and overseas squadrons is associated with the problem of finding the manpower to man and service them. Today, the R.C.A.F. has 12 CF-100 squadrons at home. Four CF-100 squadrons were despatched to Europe to replace four of the twelve Sabre squadrons abroad. The remaining eight Sabre squadrons overseas will probably keep their aircraft for some time.

Since the end of the Korean War, the Canadian economy has continued to boom in an inflationary period unprecedented in the country's history. Into it have gone hundreds of the nation's new graduate engineers, offered premium salaries by frantic consumer-goods manufacturers and even higher ones by mining and oil development companies in the Canadian West. Thus the Services have not attracted as many new engineers as they had hoped to do. In the highly technical R.C.A.F. this has become a serious problem. Pay increases for engineers with long service, and incentives on graduation to university undergraduates who take voluntary training in order to join the R.C.A.F., have been offered in greater numbers in the last few years. But still the Air Force would like to see more of these men. The new engineering graduate, however, compares the annual earnings of an experienced Air Force engineering officer with his civilian contemporary of the same age and equivalent experience. For example, a squadron leader with 15 years' service in the R.C.A.F., four of them to get his degree in engineering at a Canadian university (sometimes at the expense of the R.C.A.F.) now earns about $7,500 to $8,000 per year, compared to the better-than $11,000 to $12,000 of the average engineer of equal experience and similar age in civilian life. Many Air Force technical officers and N.C.O.s have already been offered top jobs in civilian engineering concerns on retirement, even though this may still be two, five or even eight years away. In some few cases these older, valuable men ask for a premature retirement and go into higher-paying outside industries while the opportunities are there.

How these many problems of Canada's future military aviation will be solved, is, perhaps, the main worry of the Minister of National Defence and of his Department. Already he has shown a new resilence in dealing with thorny conditions about which he was already well-informed as the former Opposition defence critic in the House of Commons.

Where the future air defence policy of his country is concerned, the gallant former major general is now guaranteed a busy year.

Straight and Level

THE managing director of a British aircraft firm was recently heard to blast: "If that aeroplane is not out by —— I'll push it out myself."

It would be unfair to identify him, for two reasons. One, the remark was made in private; two, he isn't the only British managing director who is trying to cure the dreaded malady of drifting delivery-dates.

The cure is simple: make all such remarks in public, on the record. Publish all target-dates, as the Americans do, and let it be clearly known that heads will roll if they are not achieved.

To be cagey about target-dates means only one thing. The dates will slip by, and so will the customers.

● Don't look down your nose at marine engineers, you supersonic dreamers. Before many years are past we may launch a new type of tanker for bulk transport of petroleum. It will weigh about 100,000 tons. It will be driven by nuclear power. It will travel thousands of miles at 50 to 60 knots. And, just to be different, it will cruise far below the surface of the sea.

Extensive hydrodynamic tests show that a deeply immersed body of suitable shape can be driven at 50 knots by the same power needed to propel a similarly sized surface vessel at about 30, largely owing to the great reduction in wave-making drag. How lucky we are that aeroplanes are all "deeply immersed" in a homogenous medium! For further details please apply to Mitchell Engineering, Ltd., and Saunders-Roe.

● The more I look at this futuristic ship the more I am fascinated by it. How would it navigate?—clearly by an inertial system. Could it slip through the Suez canal without paying its dues? —well, it could, I think, but nobody would let it. Could it carry and fire a ballistic missile?—well, ask the U.S. Navy. Or the Soviet Navy.

● "Big improvements to the Metropolitan" announced the London evening papers recently. They were referring not to the CV-440 but to a busy suburban railway, now part of the London Transport Executive. The improvements, unfortunately, do not affect the rolling stock, some of which has windows which resonate with the air compressors under the floor and brakes which stick-slip, causing an excruciating noise. This sort of trouble would never be allowed to get beyond the prototype stage in a transport aircraft. Before 1939, however, the Met. was a fine railway, with Pullman cars on the fast trains; and I can hardly see Convair putting a massive brass plate engraved with "live in Metro-land" on each CV-440 door.

● A *Flight* colleague was in an American D.O. the other day when in walked the smoothest nylon shirt you ever saw. The owner was in a hurry. "Look, Walt," he said, "we can't see you need all that titanium in the wing."

"Howso?"

"It'll cost three-and-a-half million bucks and we just don't need to use it; we can get away with light alloy."

"Maybe so, but we're on the limit, temperature-wise; and I'd be sorry to see us do something that couldn't be stretched to Mach 3."

"Chief engineer knows that. What he wants is an assurance from you that there'd be no way of getting past 2.6 without titanium."

"You can tell him from me that is so." "Right, three-and-a-half million dollars it is."

And that's just how it was, and the stocks were ordered within an hour.

● But don't rush off to Canada or the States. The lure of the smoothest nylon shirt you ever saw may be strong, but you can get one just as good over here —and cheaper. And you know there are design teams in the States with low morale, too.

● Most readers who have Channel 9 no doubt saw Independent Television's recent enterprising presentation of the Jack Hylton Show—filmed aboard a chartered B.O.A.C. Britannia *en route* to New York.

When I first saw the publicity-still reproduced below my thoughts went out to Bristol, in particular to their stress office. The floor-loading case presented by Miss Winifred Atwell and her "other" (honky-tonk) piano, particularly during her exposition of *I Wanna Say Hello*, must have been a bit near the limit.

From Bristol, however, came the cryptic reassurance "we looked at that one."

Among those gathered round the unique stress-case are Hughie Green, Rosalina Neri [oh boy—R.B.], and (right) Jack Hylton.

● Our fighting Services have always been noted for their reticence in taking great care never to boast of their achievements in battle. Especially is this true of the Royal Navy—the Silent Service. But any R.N. ship bearing a famous name proudly wears a large and durable plaque recording the battles fought by all ships which have borne that name. How about the famous R.A.F. airfields?

Certain famous war-time stations do have a plaque telling of the stirring deeds that were once done there, or done by aircraft operating from there. But most do not; and, as one walks along their tarmac roads, one feels that no young airman posted to such a place could feel anything but indifference to its history. He might, it is true, see that the roads might be named after people or aeroplanes—like Victor Beamish or Lysander—but he's probably never heard of either and has no particular wish to.

The Air Ministry thought of doing something in an organized manner ten years ago, and people have prodded them hundreds of times since. Could we not spare £1,000 or so (Oh-point-something per cent of the overall R.A.F. appropriation) to erect a permanent board—and I don't mean a wooden affair covered with black and white paint —outside the front gate, the guardroom or S.H.Q., so that station personnel and visitors can have *esprit* to put into their *corps*, and feel that the place really means something?

● This reminds me that nameplates of all kinds are very important devices. All too often one arrives at the main entrance of a famous aircraft company to find that there isn't really any name up at all. It may be that there is just a small brass plate beside the door (registered office variety). There may be a name and pseudo coat of arms cheaply done, or perhaps relieved in concrete letters ten feet high and shot through with dismal dribbles of rust and lichen.

Only in the newer post-war factories—which are very rarely the head office of a large company—can one expect to find the name displayed in a manner which does the firm credit. Just bring in a competent architect—and don't overrule him.

● A member of *Flight's* staff, during a visit to a Canadian aircraft company, pointed to the schedule for the first flight of a new prototype, and remarked: "That looks a bit difficult to meet."

"Oh no," came the reply, "this is the difficult one, the first production machine. The first prototype's impossible."

ROGER BACON

NEW POWER FOR THIN AIR FLIGHT

The outstanding reliability of the Napier Double Scorpion aircraft rocket engine was demonstrated by the Canberra Mk 2 which established the height record of 70,310 ft. on August 28th, 1957 in the course of routine development tests.

The Scorpion rocket engine is primarily designed to provide extra power at high altitudes where the thrust of the ordinary jet engine begins to fall off, and so enable jet propelled interceptor aircraft to operate at the heights essential for modern defence.

The Scorpion is a light, economical source of controlled power, simple to install, calling for virtually no maintenance. It burns standard gas turbine fuel, and as it carries its own oxidant, it is not affected by the low density of the air at high altitudes. In fact, its efficiency actually rises with increased height.

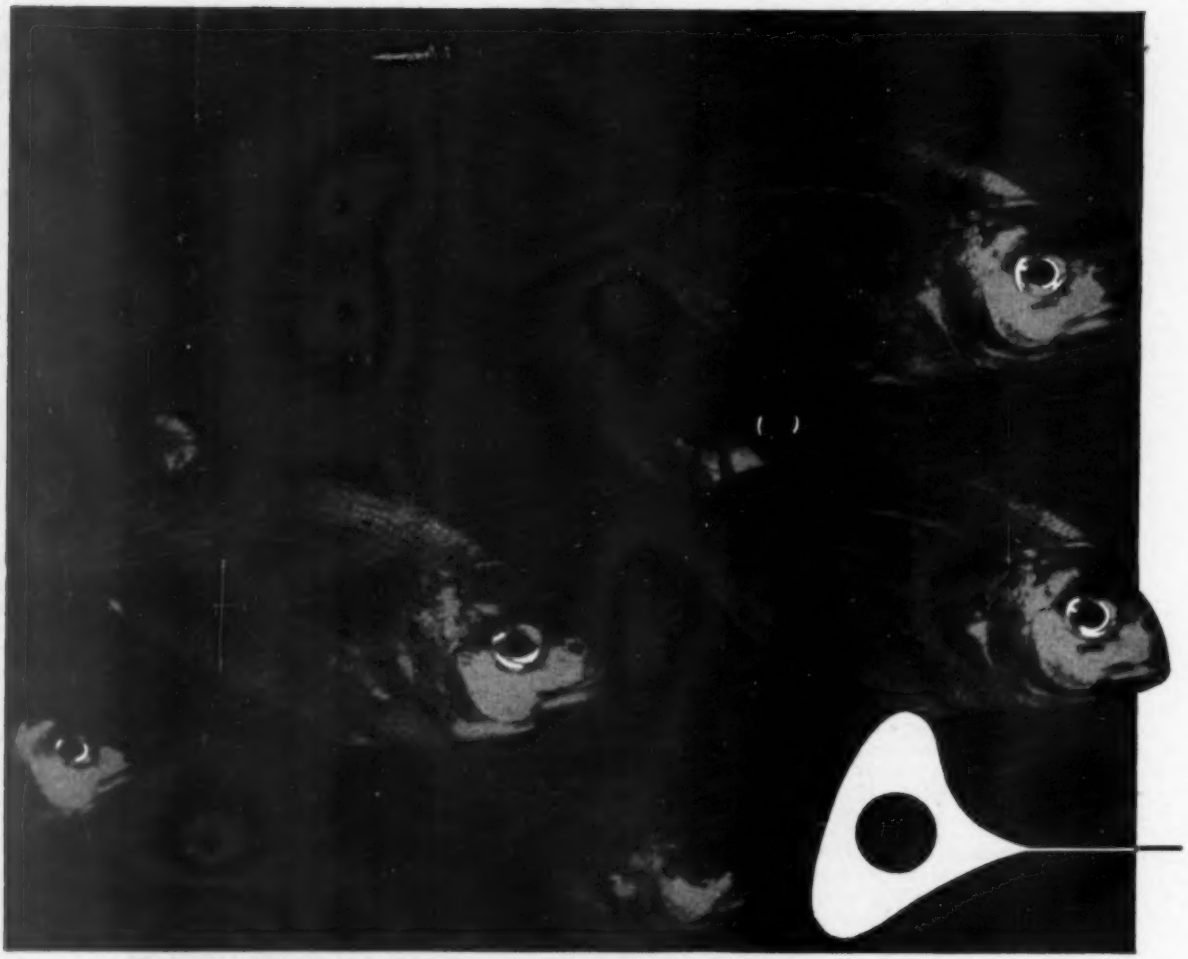
The Scorpion has been designed and developed at Napier's Flight Development Establishment at Luton, Bedfordshire.

NAPIER SCORPION AIRCRAFT ROCKET ENGINE

D. NAPIER & SON LIMITED, LONDON, W.3

A Member of the ENGLISH ELECTRIC Aviation Group

CRCR3



DUNLOP "MAXIVUE"

● DUNLOP RUBBER COMPANY LIMITED · (AVIATION DIVISION)

the unwinking eye...

THE clear eye of the fish, unwinking and unshuttered, is not troubled by the water that covers it. The shoal darts quickly through foul or fair, clear water or murk.

The "eye" of the aircraft, however, needs the supervision of the mechanical wiper. Clear, unobstructed view is naturally of the utmost importance, particularly when putting down during bad weather.

Dunlop, as usual, provides the answer to this problem.

The "Maxivue" screen wiper system is self-contained, simple, compact, extremely effective, gives a clear view forward without obstruction. All the components can safely and conveniently be mounted in the cockpit.

WINDSCREEN WIPER SYSTEMS

● *as used by many of the leading aircraft manufacturers*

• FOLESHILL · COVENTRY

7H/608

News of TACA Viscount Experience

Ricardo H. Kriete, President of TACA International Airlines, announced recently in San Salvador that in the first six weeks of operation over its routes the Vickers Viscount has shown encouraging traffic trends.

'On certain routes the load factor has been as high as 86%. The load factor over all routes on which the company operates the Viscount schedules has been 73%. Passenger reaction in our area has been most enthusiastic for the new jet-prop aircraft', said Mr. Kriete.

Passenger-appeal is often considered intangible. In the Vickers Viscount it is a conscious feature of design, based on experience. Peace of mind as well as physical comfort have been translated into practical terms, and independent studies have shown that Viscount passengers experience less fatigue than other air travellers. Built-in ease of maintenance speeds turn-round and avoids the irritation of airport delays.

All the passenger-appeal features in the new Viscount 810-840 are backed by experience based on over a million airline hours with earlier Viscounts already in service with 27 airlines. As the world's favourite airliner, the Viscount keeps passenger loads high, costs low and balance sheets healthy.

There is no substitute for experience

VICKERS-ARMSTRONGS (AIRCRAFT) LIMITED WEYBRIDGE SURREY

TGA AT 565

An international incident arose recently when this South Korean DC-3, en route from Pusan to Seoul, crossed the 38th parallel and landed in North Korea. The South Koreans say that the aircraft was "forced" across the 38th parallel; the North Koreans say that it did so because the 30 people on board had "denounced" their country's regime.

CIVIL AVIATION

PANAM'S 707 PLANS

PAN AMERICAN are planning to inaugurate Boeing 707 jet services across the North Atlantic in October—seven months from now, according to a report in *Time* magazine.

The implications of this news, which PanAm do not deny or confirm, are significant. First, it tends to confirm reports that the Boeing 707 programme is two to three months ahead of schedule: deliveries to PanAm were originally due in December. (The Douglas DC-8, incidentally, is now a little behind schedule, roll-out having been due last month and first flight this month.)

Second, it means that PanAm intend to live up to their reputation for being not just first, but first by a long way. The 707-120 may not be suitable for regular westbound non-stop operation across the North Atlantic with full payload, but its impact on traffic will be so great that its operation can almost certainly be justified commercially. The effect on B.O.A.C.'s Britannia services will probably result in a trend from *de luxe* to T.34 seating. It is significant that B.O.A.C.'s 312s are being returned to Bristol (for about a month each) so that the necessary interior changes can be made. B.O.A.C. also confirm, incidentally, that substantial changes will be made at the same time to the flight deck, where a proper flight engineer's station is to be installed.

If 707 services are in fact inaugurated in October PanAm's jet domination of the North Atlantic should be complete at least until T.W.A. introduce their 707-120s, which are due to be delivered about three months after PanAm's aeroplanes. Unless, of course, B.O.A.C. operate parallel token Comet 4 services across the North Atlantic.

The Corporation's Comets are due to be delivered in September, a month before PanAm get their 707s. The jet-race being what it is, it may well be that B.O.A.C. will be pressed to put their Comets into transatlantic service—instead of down the Kangaroo route—as soon as they are delivered. With no limitations on payload, the Comet 4 should be a good commercial proposition for a one-stop westbound operation. And at least there should be no objections in New York to the Comet's noise level, as the next news item indicates. New York's attitude to noise is a matter which could affect PanAm's inaugural plans.

The Port of New York Authority's favourable assessment of the noise of the Comet 3 was the result of tests made last November at D.H. Hatfield. A note on these tests appears on this page; here the Comet 3 is seen submitting itself to a noise-level recording by the American acoustic engineers. A total of 13 take-offs and six landings was measured.

NEW YORK AND THE COMET

THE Port of New York Authority, the world's most noise-conscious airport-owner, is satisfied that at take-off the de Havilland Comet 4 "will produce no greater noise disturbance to residential areas near airports than exists with currently used large propeller-driven aircraft."

The P.N.Y.A. has just issued its report on the measurements which its engineers made of Comet noise-levels (as suppressed by Rolls-Royce) at Hatfield between November 18 and 26 last. On the strength of its findings, the Authority has granted permission for the Comet to use New York International for demonstration flights "under controlled conditions" (e.g., in daylight and V.F.R. conditions). The possibility that the Comet 3—or more likely the Comet 4—will visit New York in the near future is not, however, confirmed as imminent by de Havilland.

ALITALIA DECIDE ON DC-8s

THE order-book for the Douglas DC-8 rose from 134 to 138 on March 6 when Alitalia-Linee Aeree Italiene (now just "Alitalia") purchased four for delivery in the summer of 1960. Cost, with spares, will be $27 million.

No indication of the choice of powerplant, which could be either Pratt and Whitney JT4s or Rolls-Royce Conways, is given. The only hard fact in the formal announcement is the Alitalia's DC-8s will be able to fly from Rome to New York non-stop against a 60 kt headwind.

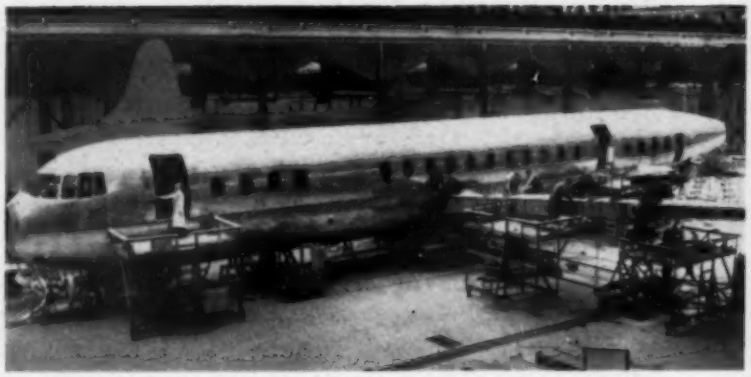
It is remarkable, incidentally, that the DC-8 delivery-date quoted by Douglas to Alitalia is the same as it would have been if the Italian airline had ordered DC-8s a year ago.

Only two other European transatlantic carriers have still to decide on big jets—T.A.P. and Iberia. Though more 707s have been ordered than DC-8s (153 *v.* 138), Douglas have 16 airlines on their books compared with Boeing's 13.

B.O.A.C. TO PARIS

APPLICATION No. 1641 to the Air Transport Advisory Council describes B.O.A.C.'s first public move to include Europe in its international network. The Corporation has requested permission to operate between London and Paris, using Britannia 312s, DC-7Cs or Boeing 707s, initially twice a week but later on a daily basis. This development was foreshadowed by last January's agreement between B.O.A.C. and B.E.A. (see *Flight*, January 31, page 158). At that time it was not clear whether B.O.A.C. would extend its North Atlantic services eastward from London, or provide a through service between N. America and the Continent by making transit stops in Europe on services to Africa and the East. The aircraft specified in the A.T.A.C. application suggest that, at least as far as Paris is concerned, a straightforward eastward extension of Atlantic services is envisaged. The extra revenue earned on this new venture has presumably been weighed against the costs involved. Superficially, it would appear that the prospects of achieving a break-even load factor on short-haul services that are scheduled to dovetail in with transatlantic services are small.

As B.E.A. have already agreed in principle to B.O.A.C.'s action, it is improbable that the A.T.A.C. will turn down the application. A more likely stumbling-block is expected to be the French Government which no doubt will reason that B.O.A.C.'s interests do not coincide with those of Air France. It is understood that the French national carrier has already sought additional rights to carry traffic between the U.K. and North America.



The great Stratocruiser-like size of the Vickers-Armstrongs Vanguard is emphasized by this new progress picture from the Weybridge works. Both wings are now attached; first flight will take place in October of this year. British European Airways are due to take delivery in March of 1960, followed by Trans-Canada Air Lines in August of that year.

CIVIL AVIATION . . .

SLICK IN TROUBLE

DURING 1957, Slick Airways are reported to have shown an operating loss of $2½m. When last month it was learnt that the situation had deteriorated even further, with a loss of as much as $½m in January alone, it was anticipated that economy measures were in the offing. At the end of the month Slick announced that scheduled freight services were to be abandoned, 500 employees laid off and 14 aircraft grounded. Slick will continue their military charters, and their service and supply activities at San Antonio, Texas.

It is just a year since Slick floated a $5m debenture issue ($3.3m of which was acquired by the Chesapeake and Ohio Railway) and negotiated bank loans up to $7m to finance an expansion programme which foresaw the purchase of six additional DC-6As.

A factor behind Slick's difficulties is the U.S. business recession. This has been accompanied by sharper competition both from improving truck transport and from larger air rivals. A notable feature of last year's freight experience in the U.S. was that the larger airlines enjoyed the fastest traffic growth. American and Flying Tiger—the two leading domestic freight carriers—expanded rapidly; freight carried by United, Slick and T.W.A. only increased marginally; while the airline lying sixth on the list, Riddle, suffered a fall in traffic.

Another development in this field: last year PanAm ousted American from its position as the leading world carrier of air freight.

DECTRA TRIALS CONTINUE

AT a meeting of the British Institution of Radio Engineers in London last week a paper on the development of Dectra over the North Atlantic was delivered by Messrs. C. Powell and D. A. Hendley of the Decca Navigator Co., Ltd. After summarizing the technical details and early tests of the system, the speakers stated that results to date "begin to suggest that the final version of the North Atlantic Dectra chain might retain the form of the single-ended layout now under test . . . rather than the double-ended one originally proposed." In this case a Decca chain might be set up in Ireland to reinforce the eastern end of Dectra coverage.

A. and A.E.E., Boscombe Down, using a Valiant and other aircraft, had completed Phase 1 tests of the system for the M.T.C.A. during eight sorties totalling 39.5 hours' flying. Astro, Doppler, Loran and Consol were used to check Dectra results; and a recorder panel was photographed automatically at 15 sec intervals. Two aerials were used for Dectra, one being an elliptical disc of 280 sq in area in the belly of the Valiant and the other a metallic-foil sheet of 80 sq ft inside the nose radome. The first was used up till 1,500 miles out from the tracking stations in Newfoundland, after which the second was connected. Both a Flight Log and a Decometer were fitted; and one chart showed that the pilot was able to follow a datum track precisely, change to Decca near England and reach a point two miles short of Boscombe runway without other navigational assistance and without sight of the ground.

Present work included shipboard trials, the setting up of permanent receivers for 24-hour evaluation, the testing of the performance over land as opposed to sea (by using "back cover" over Canada) and the evaluation of the ranging pattern with the present 120W transmitter in Britain. This last had been received at usable strength at the far-western end of the route. Evaluation of the tracking accuracy so far achieved was not yet complete, but initial investigations showed that results were good.

Historians will, we hope, look back on this picture as perhaps the most encouraging illustration to-date of the trend towards closer commercial ties between the U.S.S.R. and the West. Taken in Moscow on February 26, it shows Chief Marshal of Aviation P. F. Zhigarev, chief of Aeroflot, signing an agreement with Lord Douglas of Kirtleside, chairman of B.E.A., for the joint inauguration—later this year—of a London - Moscow service by the two airlines.

AIRLINES' DOPPLER SPECIFICATIONS

A GENERAL specification for Doppler navigation equipment for airline use has been agreed between the makers of such equipment and the airlines. Already engaged in manufacture are Decca Radar; British Marconi; Canadian Marconi; Ryan Aeronautical; General Precision Laboratory and Laboratory for Electronics; Collins; Bendix; and Radio Corporation of America. The last-named, using Marconi experience under agreement, are entering the Doppler field; and English Electric are also known to be working on equipment of this kind.

Under the new specification, aerial and transmitter units are to be separately mounted, the latter in a short 3/8 A.T.R. box. The transmitter should be able to operate with a 10ft wave-guide and minimum performance requirements up to 50,000ft and 1,000 kt have been stated. Other components should be housed in a long 3/4 A.T.R. box.

So far only Pan American are using Doppler on scheduled services, employing a G.P.L. Radan groundspeed and drift unit in a DC-7C. They report good results. G.P.L. also recently received an order for Radan from North American worth no less than $1m, but this is probably intended for the Hound Dog air-breathing air-to-surface missile and not for civil use. Deliveries are to start in June this year.

TWIN PIONEER CLEARED

THE Air Registration Board has repealed the restrictions it imposed on Twin Pioneers after the accident in Libya last December. Scottish Aviation expect that a safe life for the aircraft will be established when current wing-fatigue tests are completed—probably in June.

Twin Pioneers already on the British Register include two for British International Airlines (a B.O.A.C. subsidiary based at Kuwait); two for Fison-Airwork, to be used in the Niger Delta area under contract to Shell/B.P.; one for Malayan Airways to operate in Borneo; and three for Scottish Airlines. Not yet on the Register is the second aircraft for Malayan Airways. The first two of the R.A.F. order for 32 Twin Pioneers have already been delivered to Boscombe Down for evaluation trials.

Overseas customers and sales include the Austrian Government, 1; de Kroonduif, 3 (of which one was lost); Philippine Air Lines, 5; Iran Government, 3; Rio Tinto Mining Company, 1; Zinc Corporation of Australia, 1; Red Lion and Sun organization, 1. Film Aviation Services have chartered one Twin Pioneer for

20th Century Fox to carry personnel on location in French Equatorial Africa.

The two Fison-Airwork aircraft were those originally ordered by Transportes Aereos y Enlaces. Scottish Aviation has re-opened negotiations with T.A.E. on the sale of three aircraft for Spanish internal services.

BRITISH AIRPORT TRAFFIC IN 1957

BRITISH airports handled seven million passengers, 153,382 tons of freight and 18,196 tons of mail in 1957. Passenger traffic grew fastest, increasing by 16 per cent over the figure for 1956; freight increased by only 4 per cent; while mail fell by 2 per cent (the volume of mail had also fallen in 1956 by 2 per cent).

The number of passengers using London Airport increased from 3 million to 3½ million per annum, yet the proportion of this airport's traffic to the national total fell from 60 to 55 per cent. The next three airports in order of passengers handled were, in both years, Jersey, Manchester and Glasgow, traffic at each standing at about ½m passengers in 1957. Belfast, Prestwick and Ronaldsway (Isle of Man) each handled about 250,000 in 1957. Whereas traffic increased at each airport in the first group of three at rates above London Airport's rate of 15 per cent, that for each of the three in the second group grew only by about 6 per cent. The only other airports to handle over 100,000 passengers last year were (traffic in thousands): Blackbushe, 215; Guernsey, 200; Ferryfield, 190; Birmingham, 183; Liverpool, 150; Southend, 139; Southampton, 112; Edinburgh, 112. In this last group the fastest traffic-growth was experienced by Blackbushe (33 per cent) and Southend (78 per cent), and the slowest rate of growth by Liverpool (5 per cent).

Listed in order of freight tonnage handled in 1957 (including vehicles), Ferryfield led with 52,063 short-tons, a fall of 7 per cent on 1956. London Airport's freight traffic rose from 44,508 to 50,033 tons. Third in importance was Southend, freight tonnage having increased by 56 per cent from 12,722 to 19,756 tons. In both 1956 and 1957 these three airports together handled about 80 per cent of the national total freight tonnage. The next three airports are Southampton (7,974 tons), Manchester (6,796 tons), and Croydon (5,424 tons), together handling 13 per cent of the national total. (Southampton's traffic fell by 557 tons.) The only other airports that handled over 1,000 tons in 1957 were Jersey, Belfast, Glasgow, Isle of Man, Prestwick and Guernsey. Of these, only Jersey experienced appreciable increase over its 1956 total, while Belfast and Guernsey showed significant falls. Stansted's freight tonnage fell by more than half from 1,821 tons in 1956 to 855 tons last year.

Six-tenths of total mail in 1957 was handled at London Airport (11,017 tons), a further three-tenths being recorded at Manchester (2,762 tons), Belfast (1,891 tons) and Liverpool (853 tons). The only other airports handling large volumes of mail were Glasgow (501 tons), Croydon (263 tons) and Jersey.

COMPETITION IN THE COMMONWEALTH

A CLEAR trend is increasingly evident in the Commonwealth towards regulated competition of air transport. While not always starting from the same point—indeed, Canada and Australia until recently appeared poles apart—the Dominions have in recent years been experiencing conditions which point towards a regulated form of competition. The main two such conditions are the growth of air traffic and the long-term improvement in airline economics. This new environment, by encouraging the advent of private enterprise, has exposed both the inadequacies inherent in monopoly and the perils of unbridled competition.

No more detailed statement on the changing Commonwealth attitude has been given than the recent utterance by the Hon. George Hees, Canada's Federal Minister of Transport, in which he described the Progressive Conservative policy on air transport.

Mr. Hees has distinguished between intercontinental, transcontinental (between Canada's east and west coasts), trans-border (short routes to the U.S.), and short domestic services.

In the intercontinental field the fact of foreign competition

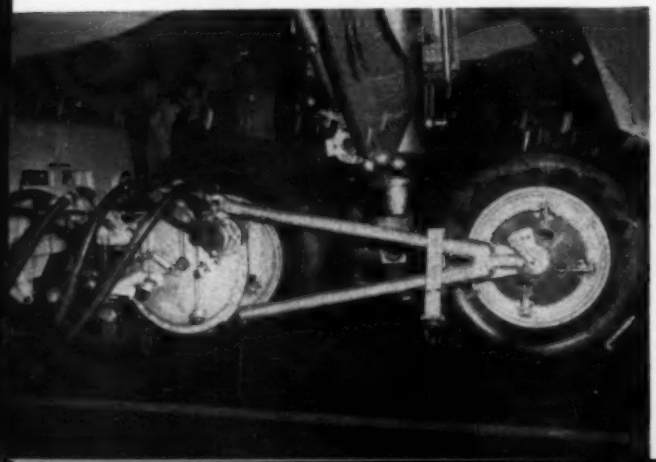
Worth watching closely is East Germany's BB.152 short-haul jet airliner, which is due to fly in May. This display model offers the first three-dimensional appraisal of the aircraft. Gross weight will be about 102,500 lb at take-off; power is provided by four "014" turbojets of about 7,000 lb thrust each; and a maximum of 72 passengers can be carried over stages of up to 1,800 st. miles at 525 m.p.h. A novel feature is the tandem undercarriage, the rear unit of which permits the aircraft to "sit down" when unstick speed is attained. The BB.152 is intended for the East German Lufthansa, but its makers say that it will be offered for sale to the West "at competitive prices."

eliminates the need for Canadian carriers to compete against each other. In the past, every international route not specifically allocated to C.P.A. was reserved for T.C.A. In the future, each application for scheduled services on an intercontinental route will be treated on its merits, subject to the avoidance of duplication of services by Canadian airlines. As regards transcontinental routes, the Air Transport Board has been instructed to proceed with a public hearing "on the general need for additional transcontinental air services." The evidence from the hearing will be fortified by an economic report on this matter prepared by Mr. Stephen Wheatcroft. Armed with this information, the Air Transport Board will be in a position to decide upon the most appropriate treatment for individual route applications.

Whereas the trans-border services are economically attractive, the short internal services are seldom self-sufficient. Government policy will be to arrange for newly licensed transcontinental carriers to accept certain short-haul routes. All trans-border services are at present operated by T.C.A., but in the future "the most suitable Canadian carrier" will be selected. Negotiations between the Canadian Government and the C.A.B. are imminent, and will be aimed at further expansion of Canada - U.S. routes, development in which the C.A.B. has in the past shown surprisingly little interest.

The philosophy behind the new Canadian policy is that which underlies the latest developments on the Australian scene. The Civil Aviation Agreement Act, 1957, passed last December, "is designed to provide fair and equal conditions of competition for Australia's two major domestic airline operators, T.A.A. and Ansett-A.N.A." Prior to this agreement a strange situation obtained. Under legislation passed in 1952, the privately owned A.N.A. received the same government assistance as the State-owned T.A.A. The price paid for this assistance—guaranteed loans, reduced landing charges, access to mail and government traffic—was that the services of each airline would be rationalized, and that in the event of a dispute the decision of an independent arbitrator would be accepted by both parties. But between 1952 and 1955 the volume of traffic carried by T.A.A. and A.N.A. showed little change, most of the extra traffic being borne by Ansett and Butler. These two airlines had introduced tourist-class fares on trunk routes and, not being parties to the rationalization agreement, were able to capture traffic from the two larger carriers.

T.A.A.'s position was strengthened by acquisition of Viscounts, but A.N.A.'s finances steadily deteriorated. The gravity of this situation was revealed last June when A.N.A. defaulted in repayment of loans and interest charges due to the Commonwealth



In "Flight" of October 4, 1957, one of the most promising solutions to the problem of big-jet terminal-behaviour was described. It was a wheel-power-unit, or more neatly "wheel-mover," for clipping to Boeing 707s and DC-8s to permit them to be taxied around—by the pilot—with engines off. Here the unit is seen attached to the prototype Boeing 707, which, it is claimed, was successfully put through a series of the most intricate manoeuvres at Seattle. The wheel-mover is by Consolidated Diesel Electric Corporation of Stamford, Conn., U.S.A.

CIVIL AVIATION . . .

Bank. A few months later all the shares in A.N.A. were purchased by Ansett Transport Industries, Ltd., the two major private airlines being merged to form Ansett-A.N.A. In the meanwhile, Ansett was acquiring a major shareholding in Butler, which airline, in turn, controls Queensland Airways.

Eclipse of A.N.A. by Ansett demanded a revision of the 1952 Agreement. Under the new Act the rationalization structure has been strengthened by establishing a rationalization committee consisting of a representative each from Ansett and T.A.A., and a "co-ordinator" nominated by the Minister of Transport. Either airline can appeal to an independent chairman, Sir John Latham, against the rationalization committee's decisions.

The first sign of the *entente cordiale* between Ansett and T.A.A. was an agreement to raise passenger fares and freight rates by an average of five per cent. Ansett's control over Butler does not yet appear to be complete, but it is unlikely that Butler will be able to disrupt the present regulation system.

In the international field, there are no signs that Qantas will cease to be Australia's single chosen instrument. The future of Tasman Empire Airways—in which the Australian Government has a 50 per cent share—is less clear. The growth of traffic on the route between New Zealand and Australia (contributing about threequarters of T.E.A.L.'s total traffic) has led to suggestions that a second carrier might well be licensed to fly across the Tasman Sea.

New Viscount insignia are these of LANICA, who have just taken possession of two new 786s from Vickers, for introduction into service between Nicaragua and Miami.

The third major Commonwealth country, India, is also allowing greater scope to its leading independent airline; Kalinga have received their Government's approval to operate certain scheduled services.

The moral of all this, surely, is twofold. One, the old country is being shown a thing or two by its younger Commonwealth partners in their enlightened regulation of private-enterprise and State-monopoly air transport. Two, such regulation is more readily applied when there exists a close-knit private-enterprise industry.

BREVITIES

AS this issue goes to press, it is learned that the Napier Eland, rated at 3,500 e.h.p., has passed its 150-hour type test.

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A Misrair Viking crashed last Friday in a sandstorm at Port Said. Four passengers and four crew were killed.

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Lebanese International Airlines have been authorized to join Air France and Air Liban in operating between Beirut and Paris.

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Swissair have installed equipment to evaluate Dectra on one of their transatlantic DC-7Cs.

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Marshal Zhigarev says that Aeroflot will put Il-18s, An-10s and Tu-114s into service "in their hundreds" during 1958.

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Austrian Airways are said to be negotiating for the purchase of Tu-104s. A route being considered would link Vienna with Tokyo by way of Moscow.

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Mr. G. N. Roberts, general manager of Tasman Empire Airways, Ltd., has tendered his resignation. He joined T.E.A.L. in 1946.

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Overseas Aviation of Jersey have purchased two Vikings from Hunting-Clan. These aircraft will be chartered to British inclusive-tour operators this summer.

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The Port of New York Authority opened a Trade Development Office in London last week. The P.N.Y.A. last year handled 1.5m tons of imports from, and 2.8m tons of exports to, Western Europe.

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Lufthansa will decide on their medium-range jet transport this year; six to ten aircraft would be required, and being considered are the Boeing 720, Convair 880, and D.H. Comet 4.

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In the description of the Viscount 810 in *Flight* of February 28 it was stated that the air conditioning system was controlled and supplied by AiResearch Equipment. It should have been noted that the system incorporates Godfrey Type-15 superchargers and Type CA-7 cold air unit, as standardized on all Viscounts.

Following the successful use of rubberized bitumen on runways at various Australian airports including Melbourne, similar material is to be adopted in Launceston, Tasmania.

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According to *Aviation Daily* the Douglas DC-9 project is now for a short-haul jet weighing 125,000 lb powered by two J75s. Delivery-date is quoted as 1962, and the price as $2.5m.

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Instead of using California Eastern Aviation's L-1049Hs between Buenos Aires and New York, Transcontinental have placed an order with Lockheed for three of these aircraft, to be delivered in April.

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A detailed analysis of the flow of New York's air traffic is to be conducted by Airborne Instruments Laboratories and the Franklin Institute Laboratories on behalf of the Airways Modernization Board.

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Eastern Air Lines have indicated a requirement for 15 to 25 medium jets. The most favourable contender is the Boeing 720, according to E.A.L.'s chairman. Mid-1961 is the "in-service" target-date.

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Sud Aviation are reported to have plans for a "Super Caravelle," to be powered by two Rolls-Royce RB.141s. Delivery would be in 1963. Air France, it is reported, may soon take up their option on 12 standard Caravelles.

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Equipment news from Australia is that Ansett-A.N.A. are interested in the Viscount (presumably 810 series), and that the same airline awaits Government approval for the purchase of four Electras. T.A.A. also await Government approval for the purchase of Viscount 810s and Caravelles.

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Mr. E. R. Quesada, chairman of the U.S. Airways Modernization Board, says that negotiations have begun with Aircraft Armaments, Inc., for the development of an electronic air traffic control simulator. It will permit comprehensive tests without the heavy expenditure of full flight experiments.

NAIROBI'S NEW AIRPORT (continued from page 327)

The control tower, 65ft high and commanding a view that can be rivalled by few airports in the world, is at the north-east end of the terminal building, where the second runway could also be easily seen. A tower of similar design is now being built at Entebbe. The control top is double glazed with anti-sun glass on the outer panels, and is air-conditioned. A lift (with the motor at the bottom of the shaft to avoid electrical interference) has been provided for movement of electrical machinery.

Into the apron are sunk eight multiple refuelling points with a total of 74 outlets. This is a combined venture by Standard Vacuum, Shell and B.P., and four types of aviation fuel will be available at a supply rate of 750 gal/min per nozzle. The tankage capacity is about 700,000 gallons. Four aircraft can be served simultaneously and bowser capacity will be available if required.

Alongside the new terminal building is a £400,000 base for East African Airways. This is a 60,000 sq ft hangar with annexes at either side. The Corporation staff have now moved from Eastleigh, prior to Embakasi becoming operative on Monday, March 10, but their DC-3 operations from Nairobi West will continue there until the base is complete. The move will be made in June and July.

Kenya can rightly be proud of her new terminal. Thoroughly modern and functional, it is a proud and permanent stake in her economic development and of that of all East Africa. Few airports, indeed, have been so confidently planned with expansion in mind, and ten years hence Kenya's civil aviation development should be comfortably within the scope of Embakasi's installation.

G/C. M. L. Gaine, C.O. of R.A.F. Yatesbury, with the first Gloster Meteor — DG202G — which he saved from destruction after it had been used as an instructional airframe for twelve years. It now stands honourably at the station entrance.

SERVICE AVIATION

Royal Air Forces and Naval Flying News

Missile Delivery

WITHIN the next few weeks the first R.A.F. ground-to-air missile, a Bristol-Ferranti Bloodhound, will be delivered to R.A.F. North Coates, where guided-weapon operational techniques are being studied and perfected. Though actual test-firings will continue at Woomera, the complete routine of preparing and launching missiles will be practised at North Coates, except for—as Air Ministry puts it—"the actual lighting of the blue paper."

The R.A.F.'s Future

CODE-NAMED Prospect, a three-day conference for senior R.A.F. officers, to discuss the responsibilities and future shape and size of the Service, will be held at Cranwell from April 16 to 18 by the Chief of the Air Staff, Marshal of the R.A.F. Sir Dermot Boyle. It will be followed by a one-day conference on May 6 at the Royal Empire Society, Northumberland Avenue, London, S.W.1, when 300 representatives of all walks of national life have been invited to a presentation and discussion of the problems involved. The C.A.S. is to address both conferences.

Vulcans in Africa

THREE Vulcans of No. 83 Sqn. Bomber Command, have been visiting Kenya, Uganda and Rhodesia during the past week. One of them flew over the new airport at Embakasi, Nairobi, last Sunday during the opening ceremony performed by Sir Evelyn Baring, Governor of Kenya; and on the following day, when the airfield was opened to the public, all three Vulcans landed there. Last Tuesday one of them was due to go to Salisbury, capital of the Federation of Rhodesia and Nyasaland. This aircraft had as co-pilot A.V-M. G. A. Walker, A.O.C. No. 1 Group, who is a former S.A.S.O. of the Rhodesian Air Training Group. It was to leave Salisbury for Waddington on March 13, the other two Vulcans having taken off for home from Embakasi the previous day.

Leeds Inauguration

WHEN, last Friday, Leeds University Air Squadron held its first annual dinner the commanding officer, S/L. P. G. South, welcomed the principal guests—Air Marshal Sir Geoffrey Tuttle, D.C.A.S.; Sir Charles Morris, the Vice-Chancellor; and A.V-M. H. V. Satterly, A.O.C. No. 64 Group—and reported that the squadron was in good heart, despite "a year of doubts and changes." It had 40 pilots and an airfield construction flight which though small in numbers was big in enthusiasm. Out of the total squadron strength of 53, only five were from the Arts faculty—the rest being either scientists or technologists. Thus it could help to bring Arts students into contact with the technological world. He put it on record that Yeadon was "the most interesting airfield in the history of aviation"—though it was not true that the R.A.F. were turning to push-button warfare because of it.

Sir Charles Morris said it was "an immense pleasure" to be present on the historic occasion when a tradition was being born. He welcomed representatives of Durham and Nottingham University Air Squadrons and in wishing Leeds U.A.S. well said that there had been "wonderful recruitment" for it, with applications for membership "very strong indeed."

Air Marshal Tuttle said that as this was the beginning of a tradition, "thank heaven you have five more years to enjoy it"; and speaking for what he called "the management" he added: "We consider that the university squadrons form an invaluable contact for the Service with civilian life."

Commenting that it was a great adventure "to come and see real people who really fly," Sir Geoffrey added: "We can't foresee the time when there'll be no aeroplanes; but when you go into the ballistic era, the problems are different. With any luck we shall end up in space with our feet on the ground."

Leeds was one of the very few university squadrons to produce a V.C. in the last war [F/Sgt. A. L. Aaron, pilot of a Stirling]. "Flying is one of the greatest things a man can do," the D.C.A.S. concluded. "It's an immense character-building thing."

Cdt. Plt. R. M. Leach, responding to the toast proposed by Air Marshal Tuttle, said that Leeds U.A.S. was delighted to have such distinguished guests at its first dinner; he referred to "that gallant band of members" who in a few weeks would be taking their P.F.B.s and who even now were "delving into the unknown depths of A.P.129"; and he paid tribute to the squadron's instructors in a home-made poem, the effect of whose stirring lines would be totally lost were they to be reproduced in after-dinner cold print.

F.A.A. Birthday Reunion

TO mark the 21st anniversary of the formation of the Fleet Air Arm, a reunion of former and serving members and ratings (both aircrew and ground branches) is being held in London on December 1 at the Royal Albert Hall.

The chairman of the organizing committee is Admiral Sir Denis Boyd, who commanded H.M.S. *Illustrious* at the time of the Taranto harbour attack, and an invitation is being extended to the 100,000 men and women who served in aircraft carriers and on Naval airfields during the Second World War and to the 50,000 so employed since 1945.

The reunion is to last from 7 p.m. to 10 p.m. and details of applications for seats will be announced shortly.

A. Cdre. J. Tester, who retires next month as assistant air defence co-ordinator at H.Q. AAFCE, with his successor, Brig-Gen. E. Kusserow of the German Air Force.

R.A.A.F. in Malaya

THIS month the first element of R.A.A.F units of the Commonwealth Strategic Reserve in Malaya—a Base Squadron, being formed at Amberley, Queensland—is going to Butterworth, the former R.A.F. station which has been rebuilt by the R.A.A.F.'s No. 2 Airfield Construction Sqn. for occupation by R.A.A.F. units of the Strategic Reserve. The base squadron is a "housekeeping unit," and present plans are that the first operational unit at Butterworth—No. 2 (Bomber) Sqn., equipped with Canberras—will fly there from Amberley on July 1. This squadron will be followed by a mobile control and reporting unit, which must be operational at Butterworth before the first fighter squadrons arrive there. The R.A.A.F. are planning to send No. 78 (Fighter) Wing H.Q. with two of its squadrons—Nos. 3 and 77, mounted on Sabres—from Williamtown, N.S.W., together with a maintenance squadron.

IN BRIEF

The Duke of Edinburgh is to visit R.A.F. Wyton, near Huntingdon, on June 24.

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Gen. Sir George Erskine, G.O.C-in-C. Southern Command, visited the Army Air Corps Centre at R.A.F. Middle Wallop on March 10 and presented wings to six student pilots who had just completed their flying training course.

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Air Marshal Sir John Whitley, Air Member for Personnel, is piloting a Canberra on an 11,890-mile tour of R.A.F. stations in M.E.A.F. He left Bassingbourn on March 10 for Cyprus and is due to return there on March 22 from Gibraltar.

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Two French Naval aircraft, the Bréguet 1050 Alise and the Fouga 170 Magister Marine, were due to carry out deck-landing trials on H.M.S. *Eagle* this week off the French Riviera after having been to the Naval Air Division of the R.A.E. Bedford for preliminary tests. The Magister Marine carried out similar trials on H.M.S. *Bulwark* last year [see *Flight* for August 16 and 30, 1957].

Aerotows for the Kent Gliding Club at Detling have recently been provided by the Tiger Club. Here pictured on a recent visit is Tiger G-AOXS.

CLUB AND GLIDING NEWS

AMBITIOUS plans are being made by Exeter Aero Club for a flying display at Exeter Airport on June 28. It is hoped that the R.A.F. and Fleet Air Arm will participate; the U.S.A.F. has promised to take part; provisional acceptances have been received from the Patrouille d'Etampes and the Zlin-mounted Czechoslovakian aerobatic team; the Tiger Club is putting on a show; the parachute section of Plymouth Aero Club are to do single and formation drops; and the Exeter Club's own staff will be giving pleasure flights during the day in Gemini, Messengers and Auster aircraft. There will be a dance that evening at the club-house.

A NEW French gain-of-height gliding record was set up by a woman pilot, Mlle. M. Dupuy de Mery, at the St. Auban national centre on February 22. Flying a Bréguet 901, she reached an absolute altitude of 29,350ft with a gain of 26,750ft. On the same day at the centre 18 flights were made above 23,000ft. The previous gain-of-height record for single-seaters—25,400ft—was set up by Mme. Gaudry in 1951.

ONE result of the recent increase in the cost of powered light-aircraft flying in Australia has been an increasing interest in gliding and soaring. One recently formed club, the New England Soaring Club, is an offshoot of the Armidale Aero Club, New South Wales, and shares the same hangar and clubrooms. At present the soaring club operates a Schneider ES-52 Kookaburra, a staggered two-seater which is used both for training and (carrying ballast) for solo cross-countries. The club intends to purchase a second machine, a single-seater, later this year.

Most launches are by auto-tow (1937 Buick and 1,500ft of drogue cable); aero-tows have often proved difficult on hot, still days, with the aerodrome at 3,500ft above sea-level. A new gliding club at Inverell has also been formed and, prior to delivery of their first ES-52, members of this club have been making the 225-mile trip to fly at Armidale at week-ends.

An even longer trip was made last month by four members of the New England club, who journeyed 700 miles in the course of a visit to the Dubbo club. A correspondent reports: "Conditions at Dubbo are fantastic, to say the least. Thousands upon thousands of acres of ploughed wheat paddocks which, under the hot sun, give rise to quantities of thermals which send the green ball of the variometer out of sight. Upon occasions it is very difficult to find enough sink to get the glider down. Many Sydney clubs spend Christmas at Narromine, 25 miles from Dubbo, taking advantage of the conditions to obtain as many Silver Cs as possible."

The 40 members of the New England club have been flying intensively during the last three months and have been assisted on several occasions by Fred Frisk, an experienced sailplane pilot from Malaya.

Air Marshal Sir Theodore N. McEvoy receives his gliding "C" from Col. M. W. J. M. Broekmijer (right), president of the Aircent Gliding Club at Fontainebleau. The occasion was the first annual dinner of this all-ranks NATO club.

A VARIETY of subjects of technical and general interest is to be covered in the papers presented at the seventh OSTIV Congress at Leszno, Poland, from June 12 to June 20. Technical papers will include discussions of profile drag, boundary layer control and new wing sections; structural methods in metal and plastics; airworthiness requirements in various countries; new developments in sailplane instruments; launching equipment; training methods; muscle-powered flight; bird flight; air medicine; speed flying and dynamic soaring. In addition, there will be descriptions by designers of sailplanes entered in the new standard class of the world championships, and papers on new designs.

In the meteorological sessions the following topics are anticipated: vertical motions in the stratosphere; structure and theory of thermal convection; and wave motions of the atmosphere. There will also be discussions of squall lines and jet streams, and one or two joint discussion sessions with experienced glider pilots.

The congress is open to all interested in the science of soaring flight, and those wishing to present papers should apply to Mr. K. G. Wilkinson, Clonard Way, Hatch End, Middlesex (aerodynamics, design and construction); Mr. Alan Yates, Bath Technical College, Bath, Somerset (general technical); Mr. Frank Irving, Imperial College, London, S.W.7 (airworthiness); Mr. B. V. Shenstone, B.E.A. Engineering Base, London Airport (muscle-powered flight); or Dr. Joachim Kuettner, 985 Metropolitan Avenue, Hyde Park, Massachusetts, U.S.A. (meteorology). Short summaries of the proposed papers should be received before May 1.

TWO courses of aviation interest are being run this year by the University of Birmingham Department of Extra-Mural Studies at the Field Studies Centre, Preston Montford, near Shrewsbury. One is a week-end course (July 4-6), in collaboration with the Shropshire Flying Club, on *Archæology from the Air*. It deals with aerial observation and photography of ancient sites, and includes lectures and demonstrations on the origin of crop marks and on flying and photographic techniques. The second is a week's course (September 20-27) on *Weather and Flight*. Organized in collaboration with the Field Studies Council, it is designed for airmen, meteorologists, physicists and mathematicians interested in the practical aspects of aeronautics. A leaflet giving details of both courses is available from the Department of Extra-Mural Studies, The University, Edmund Street, Birmingham, 3.

AVON ON CELLULOID

WE recently had an opportunity of seeing the film *The Avon Turbo Jet Engine*, made by R.H.R. Productions, Ltd., in association with the Film Producers Guild for the Rolls-Royce aero-engine school in Derby. Originally produced in 1954, it was security-classified until the beginning of this year. It gives a lucid exposition of the principles of jet propulsion, of the major components and functions of a turbojet, and finally of the Rolls-Royce Avon itself (100-series only) dealing with the mechanical design, systems, manufacture and operation of the unit. The film takes approximately 20 minutes to run and is available in 35 and 16 mm sizes from the Sound Services Library, 269 Kingston Road, Wimbledon, London, S.W.19.

COLLECTORS' PRIZES

AIRCRAFT photographs are nowadays, it seems, as big a prize for collectors as cigarette-cards once were; at least such is the change of social habit observed by the Real Photograph Co., Ltd., which has had nearly forty years' experience of supplying the public with ship, railway and aeroplane photographs. The company—which has its head office at Victoria House, Southport, and branches at Cooper's Buildings, Liverpool, and Westcliffe Arcade, Ramsgate—is particularly proud of its photographs of First World War types of aircraft (List 26W: *Warplanes of the 1914-18 War*), which is said to be the most comprehensive published in any country; but its 5,000-odd titles in stock include aircraft of many vintages, both British and American.

Research

THE ELEVENTH LOUIS BLÉRIOT LECTURE

ON March 5 the eleventh Louis Blériot Memorial Lecture was read before the A.F.I.T.A. in Paris. The author of the paper was Professor W. J. Duncan, C.B.E., D.Sc., F.R.S., F.R.Ae.S., M.I.Mech.E., Professor of Aeronautics and Fluid Mechanics at Glasgow University. His paper ranged far and wide across the fields of aerodynamics, propulsion, politics, finance, air traffic control, the dissemination of knowledge, education and other diverse factors.

The paper began with an assessment of the future outlook for aviation generally, and Professor Duncan was emboldened to state: "In my opinion the aircraft industry of the world has a tremendously important future and those nations who have a lead in this industry will unquestionably reap a great reward." He did, however, note that, although it was possible that (for example) it might fairly soon be practicable to send a reconnaissance satellite to the moon, astronautics in general would not have much influence on the aeronautical industry "for a long time to come."

Going on to discuss the basic aims of research, Professor Duncan suggested that aeronautical research was notoriously expensive, being carried out in an atmosphere of extravagance stemming from the need to win wars regardless of cost. Even in commercial aviation an atmosphere of extravagance was engendered by considerations of national prestige and, in the past, the readiness of the public to pay extravagantly for the real advantages of aerial transport. A related factor was that aeronautics had been given "an extravagant licence to become a nuisance to the public," and it was the lecturer's view that an important aim of research would be the elimination of aeronautical nuisances of all kinds.

The major part of Professor Duncan's paper was devoted to a study of eleven aspects under which aeronautical research is at present being conducted. First and foremost—since it was *the* aeronautical science *par excellence*—came aerodynamics. Under this heading Professor Duncan briefly discussed flows at very high Mach numbers and very low mean densities, and went on to point out that it was now realized that in certain circumstances, such as those pertaining to very thin wings in high-speed flight, it was advantageous to permit flow-breakaway to occur.

Turning next to the kindred subjects of materials, structures and strength, Professor Duncan emphasized the widening appreciation of the fact that the strength/fatigue/creep complex was a single subject which could be understood and mastered only through the avenue of the fundamental physics of metals. As in the case of aerodynamics, the problems of stress analysis and dynamics of aircraft structures were becoming far too complex for exact solution.

On the subject of propulsion, Professor Duncan said: "I offer no opinion about the ultimate feasibility of the atomic propulsion of aircraft. . . . It appears that the aircraft must be enormous by present standards and atomic propulsion seems unlikely to come into use for some decades." Next topic for discussion was entitled special aircraft and projects, and under this heading the author compared helicopters and other types of VTOL and STOL machines and went on to suggest that, if land-based and water-based [transport] aircraft competed on a fair footing, the latter might be found the more economical. After discussing ground installations, communications and navigation, the lecturer spoke of meteorology and made a plea for intensive work into atmospheric turbulence and for the further investigation of jet streams.

On the number and complexity of the mathematical calculations required in the design of an aircraft, Professor Duncan suggested that, while recognizing the importance of the electronic computer, he was convinced that there was still great scope for the improvement of the mathematical techniques employed. He then turned to a discussion of the problems posed by the need for disseminating the enormous output of scientific and technical papers—"so enormous that research workers are in danger of smothering themselves beneath their own products." It was not easy to make constructive suggestions, but the ultimate solution would have to depend on international and voluntary co-operation. Conferences were valuable, owing to the personal contacts made and the dynamic inspiration of the spoken word. In some countries the writers of textbooks deserved increased support, and a thought-provoking sentence at this point of the paper is "in spite of the glamour of discovery, it may soon be a more valuable service to the community to publish a lucid and accurate account of the subject than to discover new knowledge, except of a very fundamental nature."

In the next section, Professor Duncan discussed education for research. He outlined some suggested qualities which a good research worker should possess, and in his opinion the most important was "interest in the subject, coupled with energy and dogged determination." Several of the good qualities desired in a research worker truly stemmed from basic character formed at a very early age.

In his conclusion, the lecturer reiterated the view that, in future, aeronautical activities would have to be conducted in a truly economical manner and that in aeronautical research real efficiency was needed rather than narrow financial economy. Carried to the extreme, strict application of the rule "no duplication of effort" implied a complete international pooling of research programmes which at present was plainly out of the question. Actually it was the lecturer's view that, although extravagance was to be avoided, some duplication was desirable.

ROCKET GUIDANCE AND CONTROL

AT its meeting on March 1 the British Interplanetary Society heard a lecture on the guidance and control of long-range rockets. The paper was by Professor G. A. Whitfield, of the College of Aeronautics, who discussed the aiming of ballistic missiles, at the end of burning, to hit a chosen target. He noted that, to avoid too much mass being carried in the missile, the guidance was best performed while the engines were still firing, so that side-thrust could be got by tilting them. This required that, at cut-off, a combination must be obtained between missile speed, elevation angle and azimuth angle which suited the position at which cut-off occurred.

There was always a value of the elevation angle which resulted in a minimum launching speed, and operation at this angle had the further advantage that errors in angle did not have much effect on the impact point.

For the errors which might be tolerable in a ballistic missile—say, two miles at 2,000 miles' range—the cut-off velocity had to be kept within an error of 7ft/sec in about 12,000ft/sec, with an error in azimuth of about 0.1 deg.

The lecturer went on to show that radar and Doppler can give estimates of range and radial velocity which are sufficient for this purpose, and that lateral resolution is also good enough, provided there are no errors due to imperfect radio propagation. In the high atmosphere, in the presence of ionization, the velocity of propagation is appreciably different from that *in vacuo*, and considerable refraction may also occur. Alternatively to radio methods, use may be made of an inertial navigation system. This consists essentially of a platform in the vehicle which is stabilized in space by having three gyroscopes mounted on it. Three accelerometers are carried on the platform, which, by integration, give an indication of the position and velocity at any time in the flight of the vehicle. Severe limitations are given to the errors which can be tolerated in the gyros and accelerometers which are actually used: a drift of 0.2 deg/hr in the gyros, compared with about 30 deg/hr for aircraft instruments, is all that can be allowed, while zero error and hysteresis in the accelerometers must be minimized.

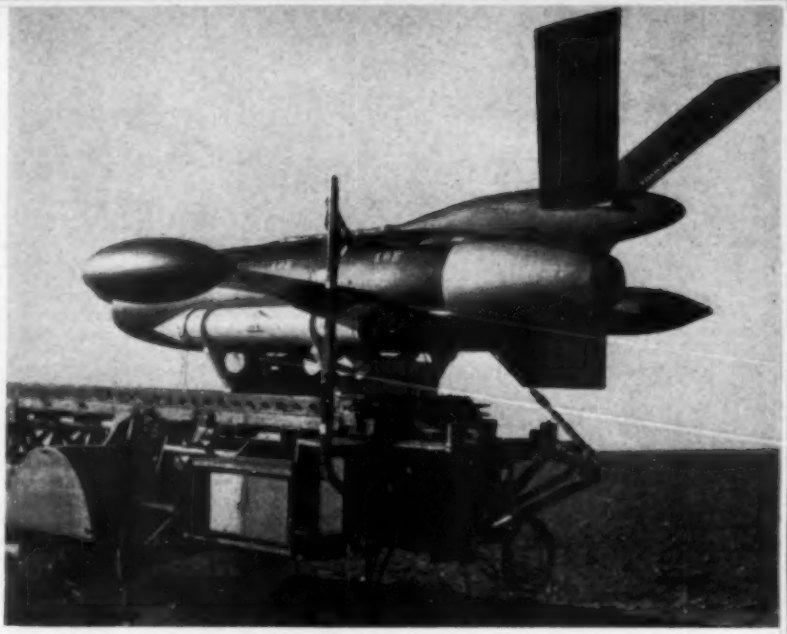
When solid-propellant motors are used for ballistic missiles it is not usually possible to arrange cut-off at an exact velocity, but the motor must be allowed to burn out completely. It is thus necessary to adjust the elevation angle to resist the velocity, and this is done continuously during firing so that the target error is minimized.

For the successful placing of a satellite vehicle in an orbit, the accuracy required in the navigation system is very much less than that needed in ballistic missiles, since quite large variations in the height of the vehicle above the Earth can be tolerated. For 100 miles' difference between apogee and perigee altitudes, a 500 m.p.h. error in cut-off velocity, or a 1 deg error in elevation, could be accepted. However, the satellite system is more complicated than the ballistic missile, since it is necessary, for efficient working, to burn the first-stage propellants fairly quickly and then let the vehicle coast up to the orbit height. This means that, unless special precautions are taken, the attitude of the later stages may be anything but horizontal and in the right azimuth when they are due to be fired, and so some stabilization must be provided. In the American Explorer vehicle, this is done by making the three solid-propellant stages, mounted on the nose of the Redstone which forms the first stage, into a large gyroscope; the cluster of motors can rotate about the launching-vehicle axis, and, before launch, it is spun up to some 750 r.p.m. This maintains the attitude of the vehicle constant in its coast after first stage cut-off; this coasting flight is made of such length that the trajectory starts to droop before the solid stages are fired, so compensating for the upward component resulting from the up-tilted attitude of the vehicle, and giving a reasonably circular orbit.

NORD CT-20 TARGET

560 m.p.h. on Marboré Power

By JAMES HAY STEVENS



A CT-20 ready for launching on the standard ramp.

THE French Nord CT-20 is the second stage in the development of a series of radio-controlled targets of contemporary performance. The first was the pulsejet CT-10—evolved from the German V-1 of unhallowed memory—which has been in use for anti-aircraft practice with the French forces, in Sweden and with the Royal Navy at Malta (it was described in *Flight* for May 25, 1956). Although the CT-20 is almost twice as fast and has a higher ceiling than its predecessor, it has the same "twist-and-steer" control system, so that there is no change in the ground equipment. Development of the CT-20 started some four years ago and the first production aircraft are now coming off the lines of Nord-Aviation (until lately SNCAN) for the French Army, Navy and Air Force; these three Services have ordered about 350, plus a follow-up contract for 250. The U.S. Mutual Weapon Development Program has contributed financially to the development of the CT-20 and has recommended its use by the U.S. 7th Army in Germany and the NATO countries.

Before describing the CT-20 itself and its associated equipment, it is worth remarking that the use of a scaled-down target aircraft for reasons of economy brings with it some related problems. For example, scale effect is even more apparent now that automatic devices have replaced visual sighting. "Corner reflectors" have to be mounted on the wing-tips—inside radio-transparent fairings—while the limited heat output of the Turboméca Marboré has to be increased by Schermuly-type smoke candles when the target is put up for infra-red-sensing missiles. Tracking for control purposes is achieved by using an I.F.F. transmitter with a transponder, which gives an operational radius of 125 miles over land, or rather better than 200 miles from ships.

Thanks to the considerable experience with the CT-10, development has gone well from the start and practically no targets have been lost. The first two flights were perfect—then there was a setback through three 'chute failures in a row. Since then all has gone well. It is understood that a projected successor for the sixties, using the developed launching and control gear and a new ramjet-powered aircraft, will provide a supersonic very-high-altitude target for surface-to-air missiles. It will be recalled that at the Paris Salon the then SNCAN showed an RJTV, the ST-450, with a speed of M=2.5 plus and a ceiling of the order of a hundred thousand feet.

The Airframe. The layout is that of a miniature aeroplane with a moderately swept mid-wing of parallel chord. The butterfly tail was adopted simply to give clearance for the recovery parachute, which is packed in the top of the fuselage. The fuselage is tailored to the diameter of the Turboméca Marboré turbojet. Construction is simple, although much thought has obviously gone into the design, and the airframe is made up from six quickly assembled—and fully interchangeable—main components.

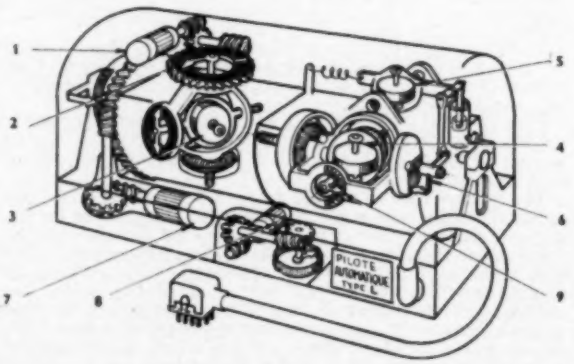
The fuselage is made in three sections. The nose is of light alloy, with—except for the glass-fibre air-intake duct—traditional structural techniques. Above the duct are the control pack, contained in a watertight cast light-alloy box, and the parachute pack, while in the port side is stowed the battery, and under the duct is the forward air-bag to cushion landing shocks. The nose bullet is an aerodynamic fairing which can be used to house recorders or other equipment up to 44 lb in weight, while a compartment in the starboard side can take 33 lb of flat equipment. All unused volumes are filled with plastic foam to ensure flotation. The centre fuselage is a mild-steel cylinder comprising the fuel and smoke-trace tanks surrounding the central intake duct. The rear part of this bay carries the wing mounting-spigot sockets, the cantilevered engine mounting brackets, the parachute support lugs and the after air-bag. The light-alloy rear fuselage cowls the engine, contains the brake parachute (in the tail bullet) and carries the tail unit fittings.

The wings are of simple two-spar design, the main spar being a steel tube, the ribs and skin of light alloy. The aerofoil section is symmetrical, so that the wings are interchangeable port and starboard on the spigot and ball-and-socket attachments. Each wing has a small rigging adjustment to absorb manufacturing tolerances in the rear attachment, which is set in the factory when the wing is offered up to a master interchangeability gauge. The trailing-edges at the tips are cut off normal to the aircraft centre-line to take the lateral-control spoilers. Although physically different from those on the CT-10 and the SS-10, these are similar in principle. The wing-tips are completed by the glass-fibre fairings which contain the radar corner reflectors.

The butterfly tail consists of two light-alloy surfaces attached to a small "centre-section" bolted to the rear fuselage. The two elevator flaps are inset in the trailing-edge and are actuated, through bell cranks, by a linkage from a centrally placed electric double-acting jack. During development flying more fin area was deemed necessary and this has been added beneath the tail. It is of light construction and is an expendable item to protect the rear fuselage when landing.

The Turboméca Marboré is a standard engine as produced in quantity for the Fouga Magister. The electrical generator has been removed and an electric actuator has been fitted to the throttle. Modifications to the stator blades to eliminate surge at high altitudes, which are now being flight-tested at Colomb-Bechar, should raise the operating ceiling to at least 46,000ft.

Control and Guidance. As the CT-20 lacks a rudder it is controlled by varying the wing-lift distribution: up, down, either level or banked. For this purpose, the autopilot has vertical and



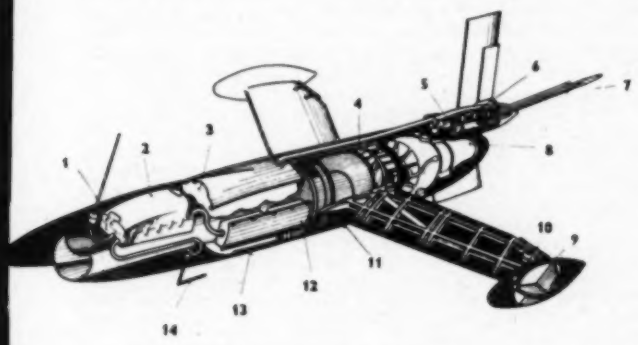
Nord target autopilot Type L (maker's diagram): 1, heading control motor; 2, heading detection potentiometer; 3, heading gyro; 4, vertical gyro; 5, gyrometer (rate gyro); 6, roll detector; 7, roll control motor; 8, dive/climb control motor; 9, dive/climb detection potentiometer.

heading gyros and a gyrometer, or lateral rate gyro, which stabilizes the aircraft in roll by signals to the solenoid-operated spoilers. Sensing devices linked to the two gyros stabilize pitch attitude and heading through the elevator servomotor.

The "pilot's" controls on the ground, in effect "set" the auto-pilot (*up, down, right, left*); the throttle (*full power, reduce power*); and also *make smoke, camera,* and *land*—nine commands in all. This is achieved by radio signals to the five-channel double-frequency modulated SFENA R-41 receiver in the CT-20. One channel is used for the four flight-attitudes and the fifth to initiate the recovery-sequence, the other commands being obtained by channel combinations, it being actually possible to provide more than nine signals should as many be required.

The landing instruction initiates a series of relay actions: fuel is cut off to stop the engine, then the brake parachute is streamed and after the retarding period the main 'chute is released. The automatic 'chute sequence starts with ejection of the tail-cone by explosive bolts and a coil spring, this releasing a pilot 'chute that draws out the main drag 'chute. The latter is so attached that as it slows the aircraft it pulls it up in a stalled attitude; then, when the strop reaches a predetermined angle, it releases the cowling over the main parachute. As the main 'chute deploys, the tension from its strop opens the CO_2 cartridges which inflate the landing air-bags.

Experience has shown that an operator can land the CT-20 within a selected area of only one kilometre (five-eighths of a mile) radius. The landing sequence is automatically initiated should the radio control signal fail to be received, so that the CT-20 "fails safe" in the event of a radio fault and cannot fly out of range.



Maker's drawing showing principal components of CT-20: 1, receiver aerial; 2, radio-control chassis; 3, main parachute stowage; 4, trace-smoke container; 5, brake parachute; 6, electric elevator jack; 7, butterfly tail with inset elevator; 8, Turboméca Marboré; 9, "corner reflector" to amplify radar response; 10, lateral-control spoiler; 11, fuel tank; 12, electrical battery; 13, landing air-bag; 14, I.F.F. responder aerial.

Final assembly of pre-production CT-20s at Nord's Chatillon-sous-Bagneux factory.

A CT-20 recovered after a flight. Expendable items include the parachute hatch panel and the lower tail fin.

Tracking. The tracking system is like that for the earlier target. There is an optical arrangement, using pedestal-mounted, graticulated, range-finding binoculars, and a radar transponder system connected to an electro-mechanical display.

A modified SFENA I.F.F. transmitter sends coded signals to the target, which its transponder re-transmits, thus allowing the slant range to be measured by the time-lapse between transmission and reception of a single pulse. A static-pressure-sensitive capsule in the transponder actuates a variable condenser which changes the duration of the return pulse with altitude. The decoded altitude information is presented on a dial and a computer converts the slant to true range. Bearing information is obtained from the orientation either of the range-finding binoculars or of the I.F.F. aerial. The bearing and range co-ordinates are fed into an electro-mechanical P.P.I. which shows the target's position on a chart by a light or stylo. The chart can have a flight plan drawn on it for the "pilot" to follow.

The control equipment can all be installed in a single large articulated trailer with a light crane mounted on the cab. In addition, a generator truck, air compressor and storage bottle unit (and, of course, the launching ramp) are needed.

Launching. The ramp is actually a two-wheel trailer of girder construction with twin 33ft launching rails—although successful launches are now being made with a new short (15ft) ramp. In use the ramp wheels are jacked clear of the ground, the forward end being supported on spreaders. The target is mounted on a sled with the two solid-fuel take-off boosters attached. The thrust of these rockets acts through the aircraft c.g. Before take-off, the sled is held back by a tension break-link.

The starting and launching sequence is as follows. The Marboré is turned by compressed air and ignited by leads from the ground supplies under landline control from the truck. The engine is then run up under radio control as a functional check. The engine is taken up to full power and the boosters are ignited, the tension link breaks and the assembly reaches about 380 m.p.h. at the end of the ramp. When the boosters burn out the sled falls away from the thrust pads and is lowered by parachute for re-use.

The CT-20 is a fully developed low-price target of representative performance, which is already in production and will be coming off the Nord-Aviation assembly lines at a very healthy rate by the end of this year. The price of the aircraft—which is normally dismantled for inspection after four flights—is low and the control equipment does not represent a high capital cost by today's standards, even if the consumable overheads per sortie do seem rather high. That a figure of as much as £40,000 has been mentioned for comparable drones, certainly makes the CT-20 look reasonably priced (figures are quoted below).

MAKER'S DATA

Span	11ft 13¼in
Length	17ft 8½in
Fuselage diameter	2ft 1in
Wing area	34.34 sq ft
Ramp length	32ft 10in
Ramp angle	+4 deg to +5 deg
Take-off weight	1,470 lb
Sea level static thrust	880 lb
Booster thrust	2 × 10,000 lb
Take-off acceleration	10g max.
Launch velocity	380 m.p.h. approx.
Climb to 32,000ft	6 min.
Mean endurance	45 min.
Service ceiling*	40,000ft
Max. speed, sea level	M = 0.73 (555 m.p.h.)
Max. speed, 30,000ft	M = 0.86 (560 m.p.h.)

Shipping Data

Case dimensions	18ft 6in × 4ft × 4ft
Total weight	2,650 lb approx.

Approximate Prices

Target, complete with charged boosters	£15,500
Consumable items:—	
Two booster charges	£255
Target components	£300
Ground control and launching equipment	£38,500
Ditto, on vehicles	£56,000
Delivery	One year

* 46,000ft with modified Marboré.

Correspondence

The Editor of "Flight" is not necessarily in agreement with the views expressed by correspondents in these columns; the names and addresses of writers, not for publication in detail, must in all cases accompany letters.

On "Selling" the Industry

I AM afraid that Mr. D. E. Rayner (*Flight*, February 21) missed the point of my letter stressing the industry's need to sell itself at home as well as abroad. And perhaps the reason was because of that word "sell"—with its unpleasant associations of brash vulgarity or monotonous repetition.

It would obviously be absurd to subject the public and the Government to the claims of the advertising business (which are surely not, as Mr. Rayner suggests, "invariably spurious"?). In suggesting that the industry could present its case more vigorously, what I had in mind was not so much advertisement as information, not merely propaganda but enlightenment.

For instance, how many of those who cherish a vision of a complacent, feather-bedded British aircraft industry existing, rather than thriving, on public money realize that this industry's £116.5m export total for 1957 is just under half the sum spent by the Government in agricultural and food grants and subsidies in the 1957-58 year? Or that the 1957 export total was just sufficient to exceed Government 1957-58 expenditure on broadcasting and housing?

Yet because the industry's achievements are solid *and* untrumpeted it has not always received the rewards that a just appreciation of those achievements should have brought. And by "rewards" I do not mean only the financial kind, but also the confidence in the ability of the industry to do a very difficult job well.

One of the root causes of the B.E.A. jet dispute—perhaps *the* root cause—was surely that the Government has lost confidence in the aircraft industry, and did not believe it capable of tackling the B.E.A. jet assignment without being told how to do so. Because the American aircraft industry is a giant, there is no reason to look down on our own industry as a pigmy, or to adopt such a "Prepare to meet thy doom" attitude towards its future.

An industry's future is based just as much on its past successes as on its present achievements. But while complacent appraisals of the former will do little good, unless the latter are known and appreciated the industry's future will never be as bright as it could be.

Rustington, Sussex. M. J. HARDY.

Making the Grade

ROGER BACON'S amusing paragraph concerning the 1913 Grade monoplane under the heading "Straight and Level" (February 21) struck a note with me. Being just as curious as your contributor I flipped through *Flight* for 1914 and found, on page 399 (April 11, 1914) another illustration of this machine. I can confirm that the pilot is looking exceedingly serious. He was Gustav Tweer and had been making trial flights on this aircraft which had been "constructed so that he can land upside-down if necessary, having chassis and wheels both above and below the planes."

Perhaps the look of grave concern on the pilot's face was caused by the thought of his approaching flight at the end of which he was to test the upper half of the undercarriage!

Hounslow, Middx. H. F. COWLEY.

Another inverted undercarriage; this photograph, taken at the 1921 Hendon Pageant, provides an appropriate PS. to the "Grade" correspondence. The aircraft was a B.E.2C (slightly modified).

"Flight" photograph

I DO not know whether or not your contributor Roger Bacon seriously wants to know what was the function of the wheels on top of the particular Grade monoplane illustrated on his page in *Flight* of February 21. They were fitted, of course, purely as a stunt for display purposes, the idea being to make an attempt to land the aircraft from the inverted position. One or two different aircraft were fitted similarly, but I do not know if attempts were made, or with what success (it would take a certain amount of courage and a lot of skill). Later Grade monoplanes, incidentally, were equipped with a nacelle for the pilot.

What a pity that with modern materials and engines a simple aircraft on these lines cannot or has not been built, today, for private purposes. But how long would it remain simple? In a short time it would be festooned with excrescences and would then have a higher-powered engine to lift it.

Naturally, of course, because early designers did not know any better, controls merely consisted of a stick and bar with cables almost direct to the surfaces. What!—simple controls like that! Today they would be considered far too simple, so a wealth of built-in cleverness would be absolutely necessary, and the operating means from the cockpit would be transmitted all round the houses before arriving at the control surfaces; then and then only could it be considered of any use. The surfaces, naturally, would move in precisely the same way.

May I reply, at the same time, to the letter from Mr. J. M. Bruce, in the same issue? He says the aircraft concerned could only have been an Ago C.I, C.II or C.III. As he says the C.III had a rotary engine, that mark is ruled out so far as the picture is concerned. I have pictures of the C.I, which shows ailerons of greater chord at the tips than inboard and balanced rudders (of Avro 504K type) and no fins. So, by elimination, Mr. Bruce's picture probably shows an Ago C.II.

Potters Bar, Middx. A. H. CURTIS.

THE photo of the Grade had a familiar look, as I had been a reader of *Flight* for two years when it was taken. Now for the published facts, all from "Foreign Aircraft News" in *Flight*:—

April 11, 1914.—A fine three-quarter-front view was shown, with this caption: "The latest idea for looping the loop. Pilot, Gustav Tweer, has been making trial flights on the above machine, constructed so that he can land upside down if necessary, having, as is seen, chassis and wheels both above and below the planes. He has been flying this machine at Bork."

April 18, 1914.—"Gustav Tweer, whose machine has landing chassis arranged on each side of the planes, as illustrated in last week's *Flight*, looped the loop at Johannisthal on the 1st inst."

June 5, 1914.—A photo of a Henry Farman appeared. Caption: "Mr. Thornely on his bi-plane at the Munster Aerodrome, where he has been giving looping exhibitions last week. . . . Tweer was also looping on a Blériot."

A Blériot! So his special machine didn't really "make the Grade" that was hoped. Normal Grade machines were the leading training type for 1913, in Germany.

Research up to the First World War fails to reveal any more news of this "reversible magic carpet."

Shepperton, Middx. CECIL H. OLIVER.

FORTHCOMING EVENTS

Mar.	14.	British Gliding Association: Annual Ball.
Mar.	14.	S.L.A.E.: "Responsibilities and Problems of the Aeronautical Inspection Directorate, by R. E. Swift.
Mar.	20.	R.Ae.S.: Guided Flight Section: "Problems in the Development of a Guided Missile," by J. Clemow.
Mar.	21.	Institute of Navigation: "The Effective Utilization of Airspace," by E. J. Dickie.
Mar. 24-27.		Physical Society's Exhibition, Horticultural Halls, London.
Mar.	25.	R.Ae.S.: Graduates' and Students' Section: A.G.M.
Mar.	27.	R.Ae.S.: The Thirteenth British Commonwealth Lecture: "Why Airlines are Hard to Please," by B. S. Shenstone.
Mar. 27-28.		Institution of Electrical Engineers: Radio and Telecommunications Section: Convention on Radio Navaids.
April	5.	British Interplanetary Society: "Problems of Handling Large Missiles," by F. R. F. Taylor.
April	10.	R.Ae.S.: Main Lecture: "Guided Weapons," by R. Cockburn.
April	11.	Helicopter Association: "Powered Lift Systems," by Charles H. Zimmerman.

R.Ae.S. Branch Fixtures (to April 30)

Mar. 17, Bristol, Barnwell Memorial Lecture, "The Economy of Structures," by Sir Alfred Pugsley; *Henlow*, Film Evening. *Mar. 19, Leicester*, "Aircraft Photography 1913-1957" by John Yoxall. *Mar. 20, Cambridge*, "The Pioneers," by N. J. Capper; *Isle of Wight*, "The Development of Powerplants for Supersonic Flight," by Dr. E. S. Moult, J. Edwards and W. Neat; *Yeovil*, "A Review of Private Flying," by A. Elsmore. *Mar. 21, Birmingham*, A Talk on Astronomy, by M. W. Ovenden. *Mar. 25, Luton*, A.G.M. and Presidential Address. *Mar. 26, Hatfield*, "Civil Airworthiness and the Air Registration Board," by R. E. Hardingham; *Preston*, "American Production Methods," by A. W. Turner. *Mar. 27, Bristol*, A.G.M. and Film Show; *Glasgow*, "Application of Electronic Control Techniques to Aircraft." *April 1, Bascombe Down*, "Aircraft Accident Investigation," by E. L. Ripley. *April 2, Weybridge*, "The Future of Nuclear Propulsion," by Rear-Admiral Sir Edward Rebbeck. *April 16, London Airport*, "Titanium," by H. W. Shaw; *Preston*, Annual General Meeting. *April 23, Leicester*, A.G.M. *April 30, Weybridge*, A.G.M.

AERONAUTICAL BOOKSHELF

Three Steps to Victory, by Sir Robert Watson-Watt. Odhams Press, Ltd., 96 Long Acre, London, W.C.2. Illustrated. Price 30s.

OCCASIONALLY an inventor wants to let the world know how the inventions with which he is popularly credited really came about. This is what Sir Robert Watson-Watt has done in this personal account of his radar work—and also of his younger days, for the book is really an autobiography.

The three steps to which Sir Robert lays "an unhedged and unashamed claim" were radar (as most of us know), the clumsily named, though certainly vital, Instantaneous Visual Radio Direction Finder and, surprisingly perhaps, the science of operational research. Whether or not this third item was really "invented" is debatable, but the author says that when he began producing his other inventions no one had seriously thought of the importance of matching the new equipment to actual conditions in the field. So he thought out the system—and with it the boffin. The boffin, he says, is quite different from the back-room boy, although their pedigrees have certain dominant strains in common with each other. He is not quite sure of the true origins of the name boffin, but "it certainly has something to do with an obsolete type of aircraft called the Baffin, and something to do with that odd bird, the Puffin." He continues: "The indispensable characteristics of the Boffin include an insatiable curiosity, an indomitable insistence and an inherent indiscipline. . . . The Boffin bird has a long bill with two special functions: poking into other people's business, and puncturing the more highly coloured and ornate eggs of the 'Lesser Back Room Bird' which are quite inappropriate to the military scene."

This is typical of Sir Robert's literary style. The man himself probably has that intellectual twinkle in his eye which is often the hallmark of a scientist, plus the rare ability to express himself concisely and entertainingly. He has written this book primarily for (I think!) the layman. But every now and then, as if tiring of the effort to write simply, he wanders away in a relieving burst of technical jargon. His is an encyclopædic account revealing some of the innermost secrets of the many versions of radar which undoubtedly made our chances of winning the war far brighter than they would have been without it. The reader with a general interest will find the story full of the details and the excitement of the long programme of radar research which began, if we seek its very beginnings, 40 years ago, continued in the seclusion of a few Government establishments in the 1930s and is today a major industry.

A. C. B.

They Fought for the Sky, by Quentin Reynolds. Cassell and Co., Ltd., 35 Red Lion Square, London, W.C.1. Illustrated. Price 21s.

A BOOK that will doubtless have a strong popular appeal, especially to those whose acquaintance with aircraft and aerial warfare is neither intimate nor critical. *They Fought for the Sky* was written out of admiration for the aircrews of the 1914-18 war, and the dust-jacket blurb informs us that it ". . . tells the full story of the British, French, German and American flyers of World War I and of the development of the aeroplane as a fighting machine."

It tells a good deal about the "flyers," but it scarcely scratches the surface of the development of the fighting aeroplane. The great majority of the men mentioned were the best-known fighter pilots of their respective nationalities, but American pilots are given considerably more space than they deserve: the names of many who shot down nothing are to be found, but there is no mention of (for instance) the R.F.C. officers Trollope, Woollett and Claxton, each of whom shot down six enemy aircraft *in one day*.

The author has placed a premium on action; consequently the book is readable and stimulating in the popular sense.

Mr. Reynolds cheerfully admits that he has taken passages from other books, citing as his aegis an apophthegm which is of doubtful validity. He has indeed taken sizeable chunks, reproduced word for unabashed word in many cases. That of itself is not necessarily a bad thing in a book of this kind, but some of his reference sources are unreliable, and his uncritical acceptance of them has perpetuated errors committed by others. This has proved particularly unfortunate where references to aircraft are concerned. Inevitably, the great Fokker myth is revivified and repeated *ad nauseam*: the truth is that, so far from "turning out almost 60 distinct aircraft designs from 1914 to 1918," Fokker did not—could not—design one of them. The Sopwith Triplane history is, as usual, misrepresented. One reads with alarm of "wing warping instead of loose ailerons"; with amusement that "the B.E. . . . had many features of the original Bleriot"; and with incredulity that the bird-in-the-birdcage chestnut related originally to the Blériot monoplane! "Bloody April" is adroitly postponed until 1918 to add drama to Richthofen's death; Bishop is still flying a Nieuport at the end of his operational career; and several names are mis-spelt.

Martin MB-1 bomber, seen with certain famous personages identified in the review, below, of "A History of the United States Air Force."

The illustrations are numerous and very good, but one refuses to believe that any D.H.4 (even the American one illustrated) which "released its missiles over the front," would carry no guns when doing so.

The reader is, regrettably, left with the impression that, for all the reading and (dare one say?) research that Mr. Reynolds has done, he is still not quite *au fait* with the men and machines of which he writes.

J.M.B.

A History of the United States Air Force, 1907-1957, edited by Alfred Goldberg. D. Van Nostrand Co., Ltd., 358 Kensington High Street, London, W.14. Illustrated. Price 51s.

THE story of the United States Air Force since it began 50 years ago is admirably covered in a large volume based on an official history. There is much fascinating detail about the early years of the Service, and some hundreds of photographs, including that above, showing what is erroneously described as the only American-designed combat aircraft developed during the 1914-18 war—the twin-engined Martin MB-1 bomber. This aircraft came into use in the early 1920s and is seen above (in 1918) with Lawrence Bell, Eric Springer, Glenn Martin and Donald Douglas.

Jet Planes Work Like This, by John W. R. Taylor. Phœnix House, Ltd., 38 William IV Street, Charing Cross, London. Price 9s 6d. Illustrated.

WHEN the jet engine first appeared it was heralded as the simplest thing of its kind imaginable. It had one moving part and would cure all the headaches suffered by the designers and operators of aircraft who before had to use rattling and shaking piston engines! The over-simplification of that propaganda was well intended, and John Taylor has sought to maintain that sort of simple language in this book. He explains in a minimum of words how jet engines work, why an aircraft has to be pressurized, and how fixed wings take over the support of a VTO once it begins to move forward. John Wood's drawings bear similar hallmarks of simplicity and will answer many of the questions posed by the enthusiastic youngster—and by those who are just as interested but perhaps not quite so young.

OTHER BOOKS RECEIVED*

Aeromodeller Annual 1957-8, compiled and edited by C. S. Rushbrooke and D. J. Laidlaw-Dickson. The Model Aeronautical Press, Ltd., 38 Clarendon Road, Watford, Herts. Price 10s.

Space Flight and Satellite Vehicles, by R. B. Beard and A. C. Rotherham. George Newnes, Ltd., Tower House, Southampton Street, Strand, London, W.C.2. Price 15s.

Dynamic Instability, by Y. Rocard. Crosby Lockwood and Son, Ltd., 26 Old Brompton Road, London, S.W.7. Price 45s.

Rockets, Missiles, and Space Travel (second edition), by Willy Ley. Chapman and Hall, Ltd., 37 Essex Street, London, W.C.2. Price 50s.

After the Monsoon, by Oliver Moxon. Robert Hale, Ltd., 63 Old Brompton Road, London, S.W.7. Price 15s.

Annual Report of the Smithsonian Institution, 1956, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Price $4.50.

Atom Plane Mystery, by Eric Leyland and T. E. Scott-Chard. Edmund Ward (Publishers), Ltd., 194-200 Bishopsgate, London, E.C.2. Price 7s 6d.

Aircraft Mechanic's Pocket Manual, Fifth Edition, by Joseph A. Ashkouti. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price 20s.

"The Engineer" Buyers Guide, 1958. The Manager, "The Engineer," 28 Essex Street, Strand, London, W.C.2. Price 7s 6d.

W.O. The Autobiography of W. O. Bentley. Hutchinson and Co. (Publishers), Ltd., 178-202 Great Portland Street, London, W.1. Price 21s.

Project Satellite, edited by Kenneth W. Gatland. Allan Wingate (Publishers), Ltd., 12 Beauchamp Place, London, S.W.3. Price 21s.

**Some of the books named may be reviewed in future issues.*

Personalities at two apprentice prizegivings reported below. On the left, at Handley Page (Reading), Mr. Airey Neave—with Sir Frederick Handley Page in the background—presents a diploma to K. A. Campion. In the second picture, at Armstrong Siddeley, are (l. to r.) Alan Stevens, receiving the award for the best all-round apprentice; Pat Davenport, best craft apprentice; Mr. H. T. Chapman (mg. dir.) and Robert Carey.

THE INDUSTRY

Handley Page (Reading) Prizegiving

APPRENTICES and parents at the annual prizegiving of Handley Page (Reading), Ltd., at the company's Woodley works on February 15 were addressed by Mr. Airey Neave, Joint Parliamentary Secretary, M.T.C.A., who presented the awards.

The aircraft industry, said Mr. Neave, needed new men and forceful personalities. He foresaw for it a bright future, and added that the Government would do what it could to help exports and the formation of the industry into stronger units. He was glad to have "escaped" from the House of Commons for the occasion, in company with A. Cdre. Sir Arthur Vere Harvey, the company's deputy chairman.

Sir Frederick Handley Page, chairman and managing director, described the company's training scheme at Woodley, which was based on that recommended by the S.B.A.C. He mentioned the many senior executives of the company who were former apprentices, and said the company hoped in future to draw all its principal staff from this source.

Mr. J. Brosgall, secretary to the Southern Regional Committee for Further Education, reviewed the work of the technical colleges where the Woodley apprentices received theoretical education.

Dowty Hydraulics Appointment

APPOINTED to the Board of Dowty Hydraulic Units, Ltd., as production director, Mr. L. S. Flatman, C.B.E., A.M.I.Mech.E., joined the company on February 3 from the Ministry of Supply, for whom he had been Director of Ordnance Factories since 1953, travelling extensively in Europe and North America in the course of his duties. Until his resignation from the Ministry, he had also been a member of two NATO technical committees.

Armstrong Siddeley Outlook

PROSPECTS of mounting business and full employment for at least three years were forecast by Mr. H. T. Chapman, managing director of Armstrong Siddeley Motors, Ltd., in a speech at the company's Apprentice Association dinner. This, he said, was despite the effect of "staggering" defence cuts announced in the Defence White Paper last year.

Before the cuts the firm had taken on what he believed was the biggest Government contract of its kind—for supersonic bomber engines [these would have powered the Avro 730—Ed.]. The contract was lost, and the company's development work was cut severely. "I suppose of the five major aero-engine concerns in this country," said Mr. Chapman, "we had the roughest deal. Nine to ten months ago you could have had my job for three-ha'pence. But you don't live in engineering by getting your tail down."

The company had accordingly decided to try to capture the semi-light-engine field, with the 1,000 h.p. class of turboprop for helicopters and fixed-wing aircraft. A vast amount of money had been received from the parent Hawker Siddeley Group for this private venture.

In addition to a considerable amount of sub-contract work the firm was at present making the Viper engine, for which many inquiries had been received from America. Prospects for the T.100 gas generator project were promising, and another big job was the German Maybach 1,200 h.p. diesel, which they hoped to produce under contract for British Railways.

After a speech by Mr. J. E. Attwood, director and general manager, and others by Mr. T. Barber and Mr. R. Pettifor, respectively chairman and secretary of the Association, tournament awards were presented by the company's secretary, Mr. F. T. Blakey. Mr. W. H. Lindsey, technical director, was in the chair.

Data on Materials

TO supply industry, universities, technical colleges and individuals with complete information on any type of material, an organization known as Materials Data, Ltd., has been set up with an information centre at 273 Farnborough Road, Farnborough, Hants. It exists to make readily accessible technical data on all types of materials, including metals, refractories, woods, adhesives and plastics. This information is supplied on data cards, or members can visit the centre and make use of its facilities to answer their queries. Membership is open to any company, manufacturer or individual paying a fee of 12 guineas per annum, while temporary membership may be arranged at reduced rates. The organization originated in a suggestion by Mr. P. Bishop, a scientific officer at R.A.E. Farnborough, that it would be useful to arrange a collection of materials—not restricted to any particular type—and set alongside each sample standardized "material data cards" containing all the information commonly required (strengths, sources, costs, etc.). Such data cards are now forwarded to any member requesting information.

IN BRIEF

Mr. D. A. Hubbard has been appointed a director of Aero Research, Ltd. He joined them in 1939 and shortly afterwards took charge of production. In 1947 he was appointed works manager, with special responsibility for the planning and commissioning of the large-scale production facilities initiated at Duxford since that time.

Contracts manager of the Fairey Aviation Co., Ltd., since March 1944, Mr. Harold Chennell has now retired, having served with the company for 33 years and during that time been involved in all its major contracts. He joined Fairey Aviation in 1924 as assistant accountant and became assistant secretary in 1934.

* * *

Mr. E. A. Croker, who joined Douglas Equipment, Ltd., in July last year as commercial manager, has been made a director.

* * *

Mr. G. F. Lawrence has been appointed to the Board of Metalastik, Ltd. He joined the company last September as personal assistant to Mr. M. Goldsmith, chairman and managing director.

* * *

After fourteen years with the Northern Aluminium Co., Ltd., in posts ranging from head of the sales development division to his present position as head of the sales department, Mr. J. H. Mayes has joined the company's Board.

* * *

Plans are now complete for the erection of a new factory at Treforest, Glam, to house Firth Cleveland Instruments, Ltd. (newly formed last May as a subsidiary of Simmonds Aerocessories, Ltd., whose main premises it will adjoin). The factory, which is now marketing the instruments produced by Simmonds Aerocessories, will when completed also take over production.

* * *

Decca Radar, Ltd., and the Decca Navigator Co., Ltd., have moved their head offices into a new building on the Albert Embankment and their address is now Decca House, Albert Embankment, London, S.E.11. It is one of the imposing new structures adjoining the London Fire Brigade Headquarters and is within easy access of Lambeth Pier, a boarding-point for the marine radar demonstrations by the company's vessel *Navigator*.

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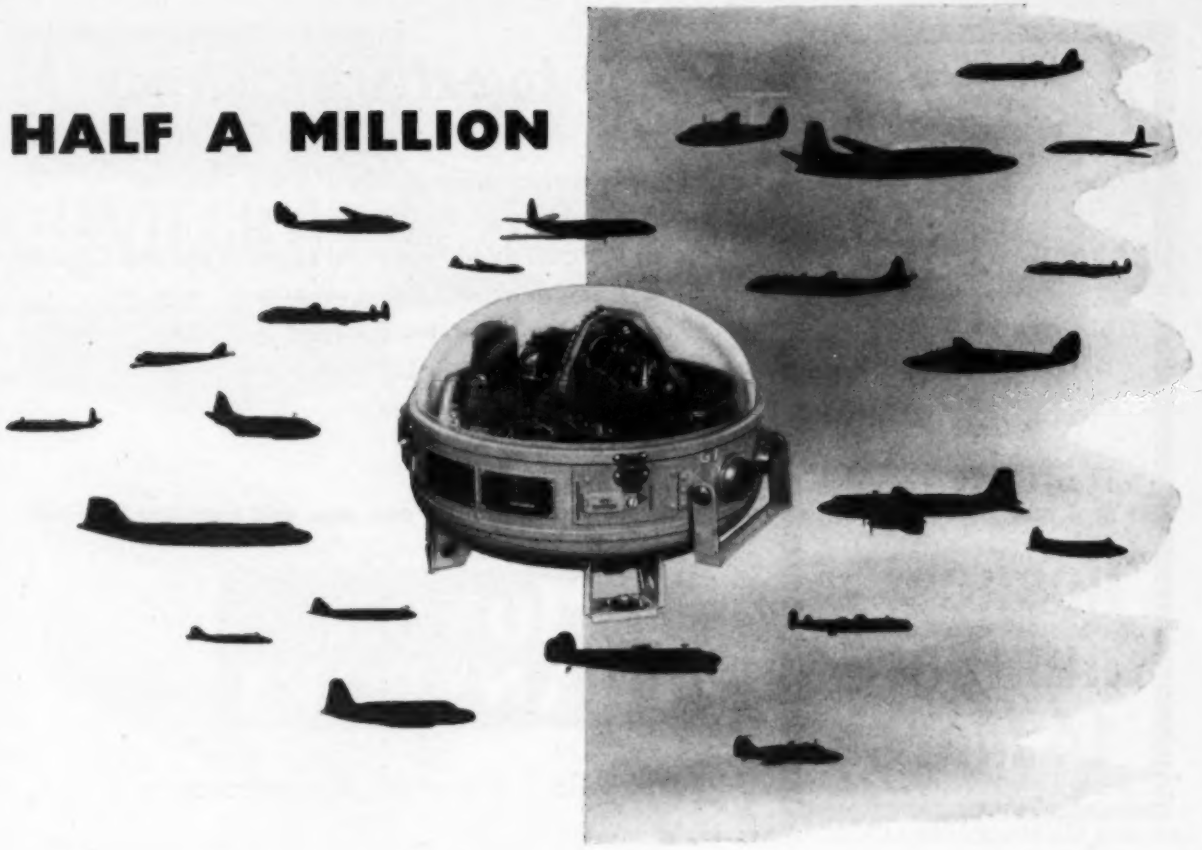

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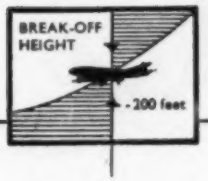

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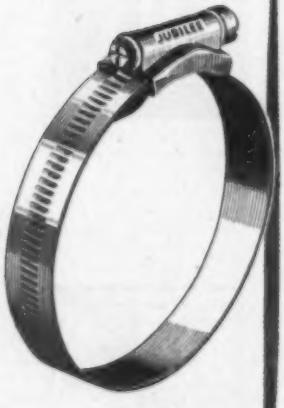

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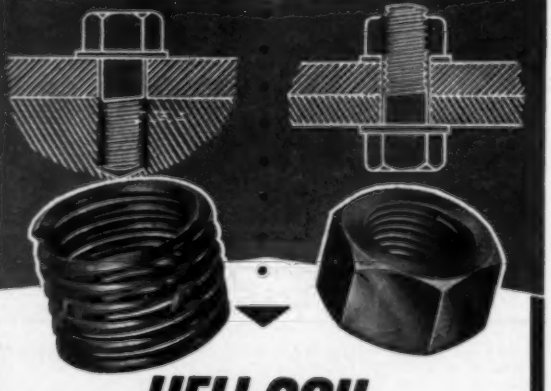

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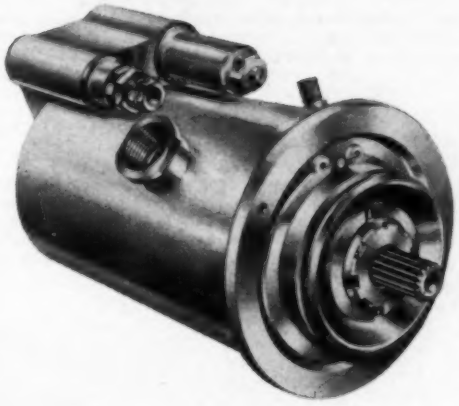

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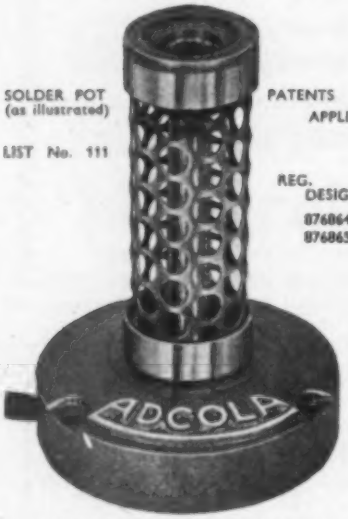

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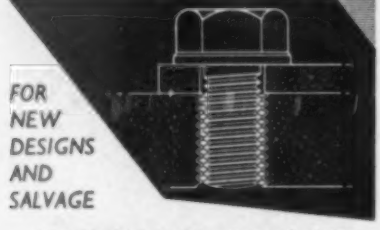

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APPLICATION No. 1647 from Airwork, Ltd., of 35, Piccadilly, London, W.1, for the following increases and variations in the frequencies of their services to Africa:—

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(b) from two return flights each 28 days to 39 return flights per annum on their Coach Class Service between London and Salisbury (S. Rhodesia);

(c) from four return flights each 28 days to 52 return flights per annum on their Coach Class Service between London and Nairobi.

APPLICATION No. 1648 from B.K.S. Air Transport, Ltd., of 1, Marylebone High Street, London, W.1, for a Normal Scheduled Service with Dakota and Ambassador aircraft for the carriage of passengers, supplementary freight and mail between Leeds (Yeadon) and Basle at a frequency of two return flights weekly for seven years from 1st April, 1958.

THESE applications will be considered by the Council under the Terms of Reference issued to them by the Minister of Civil Aviation on 30th July, 1952. Any representations or objections with regard to these applications must be made in writing stating the reasons and must reach the Council within 14 days of the date of this advertisement, addressed to the Secretary, Air Transport Advisory Council, 3, Dean's Yard, London, S.W.1, from whom further details of the applications may be obtained. When an objection is made to an application by another air transport company on the grounds that they are applying to operate the route or part of route in question, their application, if not already submitted to the Council, should reach them within the period allowed for the making of representations or objections. [7668

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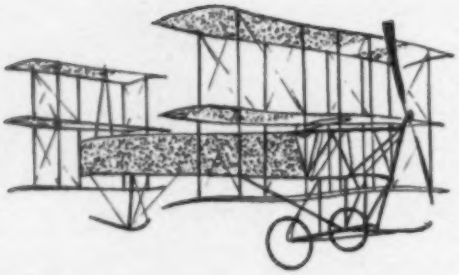

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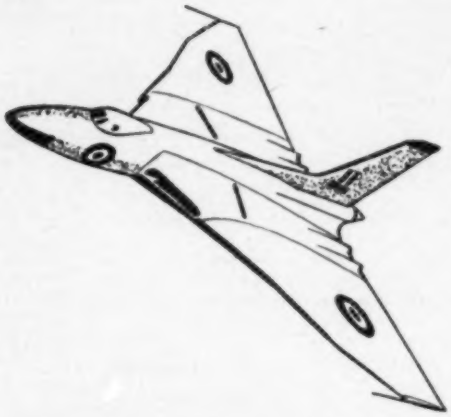

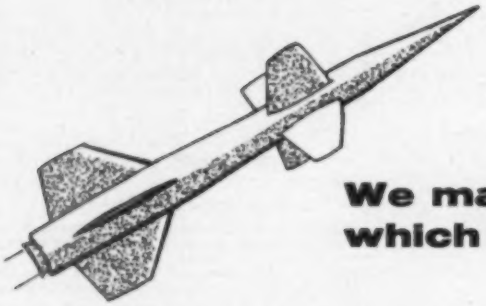

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	Page
Adcola Products, Ltd.	30
Armstrong Patents Co., Ltd.	28
Armstrong Whitworth Aircraft, Ltd., Sir W. G.	16
"Autocar, The"	6
Avica Equipment, Ltd.	10
Bellman Hangars, Ltd.	12
B.R.D. Co., Ltd.	9
Bristol Aero-Engines, Ltd.	Cover iv
Burnley Aircraft Products, Ltd.	14
Carr Fastener Co., Ltd.	10
Central African Airways Corporation	35
Coley and Son (Hounslow), Ltd., R. J.	29
Cross Manufacturing Co. (1938), Ltd.	30, 32
Cyprus Airways, Ltd.	31
De Havilland Propellers, Ltd.	18, 19
Delaney Gallay, Ltd.	20
Derby Aviation, Ltd.	30
Dunlop Rubber Co., Ltd.	24, 25, 35
English Electric Co., Ltd., The	35
Fairey Aviation Co., Ltd., The	Facing Edit. Page 334
Fishers	32
Fokker	1
Goodlin, Chalmers H.	30
Hobson, Ltd., H. M.	11
Hymatic Engineering Co., Ltd., The	5
Iliffe and Sons, Ltd.	6, 28
Integral, Ltd.	29
Jessop and Sons, Ltd., Wm.	13
London School of Air Navigation, Ltd.	32
Lucas (Gas Turbine Equipment), Ltd., Joseph	Cover iii
Marshall's Flying School, Ltd.	32, 33, 35, 36
Martin-Baker Aircraft Co., Ltd.	Facing Edit. Page 335
"Motor Transport"	28
Napier and Son, Ltd., D.	23
Robinson and Co. (Gillingham), Ltd., L.	28
Roe and Co., Ltd., A. V.	34, 36
Rolls-Royce, Ltd.	17
Royal Dutch Shell Group, The	33
Royal Rhodesian Air Force	33
Rozalex, Ltd.	32
Simmonds Aerocessories, Ltd.	15
Smiths Aircraft Instruments, Ltd.	27
State Express Cigarettes	Cover ii
Strutt and Parker, Lofts and Warner	31
Teddington Aircraft Controls, Ltd.	8
Teleflex Products, Ltd.	4
Texas Instruments, Ltd.	7
Thompson Brothers (Bilston), Ltd.	14
Triplex Safety Glass Co., Ltd.	8
United Aircraft Export Corporation	2, 3
University of Birmingham	33
Venner Accumulators, Ltd.	12
Vickers-Armstrongs (Aircraft), Ltd.	26, Cover i

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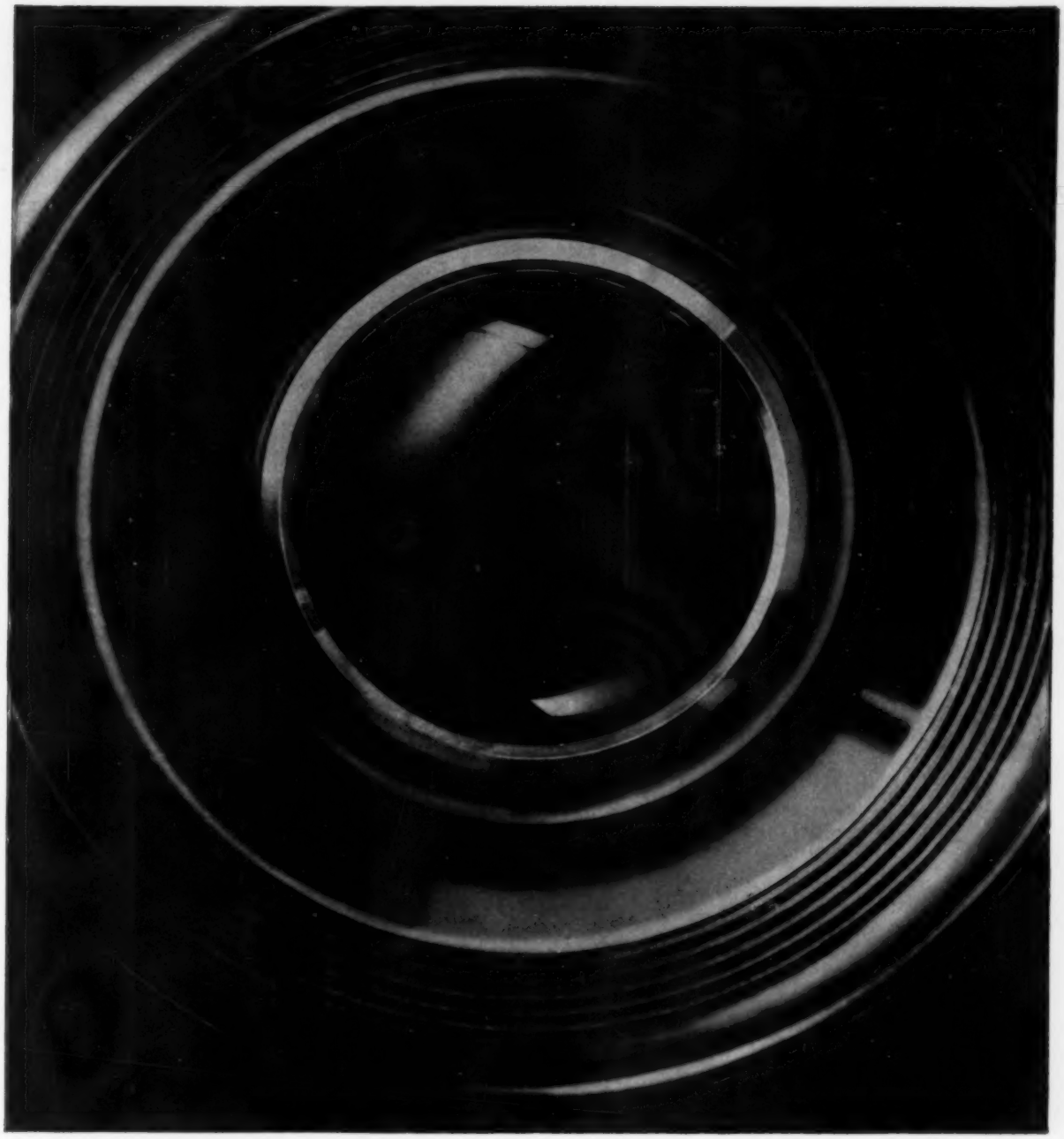

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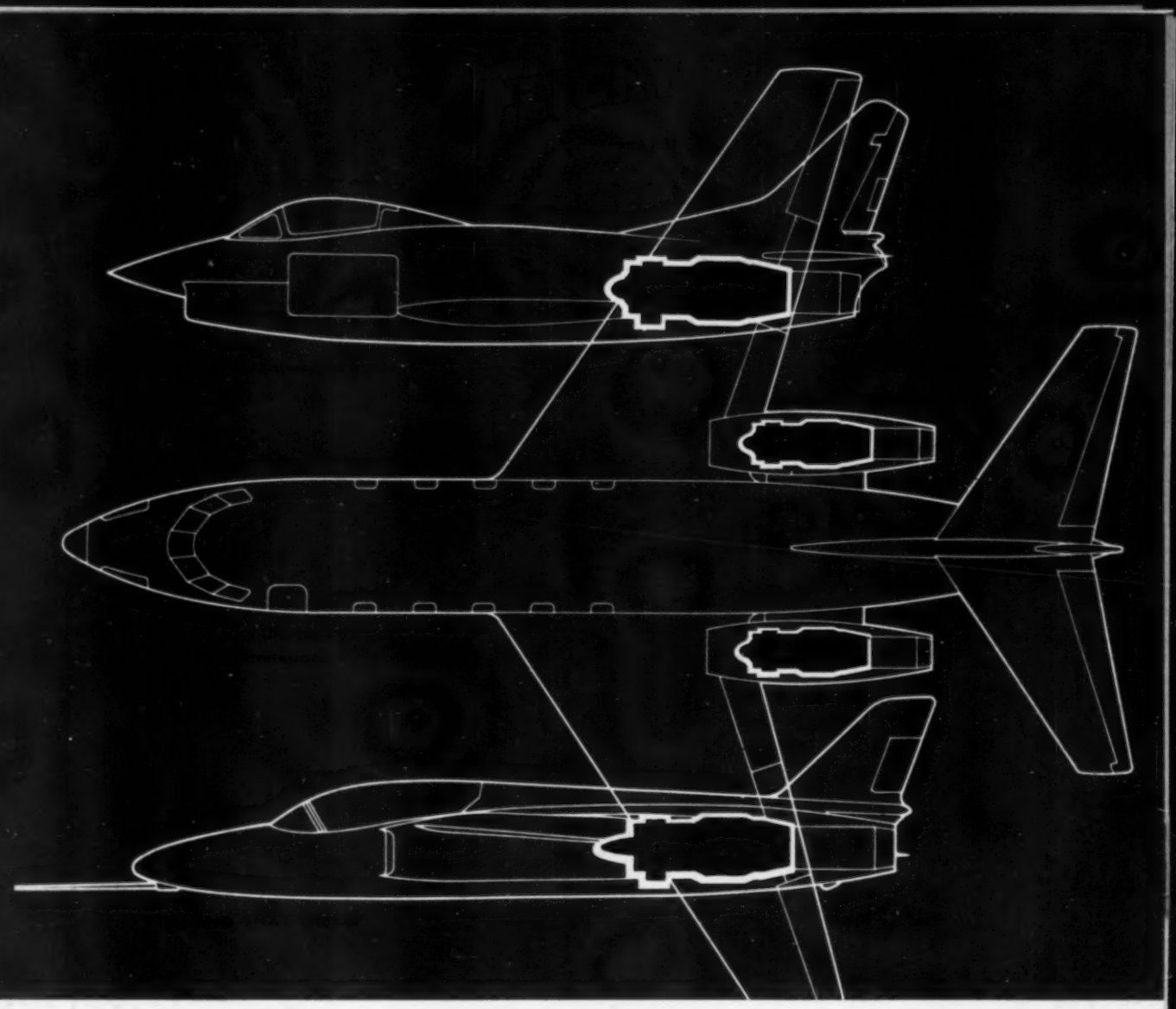

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